Bonnell & Lundahl

Experiments
With Fan Blowers

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EXPERIMENTS WITH FAN BLOWERS

BY

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AND

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THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

EVERETT SHANNON BONNELL and BRUCE HJALMAR LUNDAHL

ENTITLED EXPERIMENTS WITH FAN BLOWERS

IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE DEGREE

OF Bachelor of Science in Mechanical Engineering

L. P. Breckenridge

HEAD OF DEPARTMENT OF Mechanical Engineering

Introduction.

The ordinary centrifugal fan or exhauster consists of a number of blades fixed to arms, revolving on a shaft at high speed. These blades usually are inclosed in a casing which is alwasys of a spiral form. They are adapted to the movement of large volumes of air at pressures varying from one to twenty ounces. With a fan the air is generally discharged into the atmosphere, while with the exhauster it is drawn from the atmosphere.

Classification.— The classification of centrifugal fans is as follows:-

Steel Pressure Blowers.

Volume Blowers.
Volume Exhausters.
Steel Plate Blowers, and Exhausters.
Sirocco Blowers.

Steel Pressure Blowers.

The steel pressure blower is a fan designed to deliver a small volume of air at a high pressure. They are capable of producing a pressure of as high as twenty ounces, and are adapted for use with cupolas, forges and mechanical stokers. In order to obtain a small volume of discharge at a high pressure, pressure blowers are made with blast wheels of small widths as compared to their diameters. The blades, varying in number from

-five to eight, are wider at their inner ends than at their outer circumference, where they are curved backward to allow the air to easily leave the wheel, and to diminish the noise of the fan when running at a high rate of speed. The Sturtevant pressure blowers are built with six blades and twelve or eighteen smaller ones. These small blades are of about half the length as the large ones, between which they are placed. The large blades are all riveted to "T" irons cast on the hub of the blast wheel, while the small blades are riveted to and carried by the conical side plates which extend from the inlet to the outer

circumference of the wheel. The side plates in turn are carried by the large blades of the wheel. The casing, always of a spiral form, is made of cast iron and usually has its discharge opening horizontal and at the bottom. The shaft is of steel and is hung in two large selfoiling bearings, generally of the ring and wick type. A bearing is placed on each side of the fan casing and supported by a pedestal which is either cast on the casing or bolted to it. Both one and two driving pulleys are used. Pressure Blowers are always mounted on an adjustable bed plate but are never directly connected to the engine, as the

relative speed is too high.

Volume Blowers.

This type of blower is designed and built to discharge a large volume of air against a moderate pressure, two to ten ounces per square inch. In appearance they are very similiar to the pressure blowers. The casing, however, is wider and the outlet larger in proportion than in the former. The fan blades in some cases are of an equal width the whole length and are also bent backward as in the pressure blowers. Only one driving pulley is used. Volume blowers also are mounted on adjustable bed plates, and if the relative speed is not to

high may be directly connected to the engine.

Volume Exhausters.

The construction of the general type of volume exhausters is not unlike that of the volume blower, except that there is only one inlet and that the shaft is overhung in two bearings, both of which are placed on the opposite side of the casing from the inlet. The bearings have the driving pulley placed between them and are supported by pedestals in the same manner as in the blower.

Steel Plate Blowers and Exhausters.

This line of blowers and exhausters is built to handle large

volumes of air at very low pressures, such as are wanted for ventilating purposes, where this type of fan finds a large field of application. The casing is of steel plate riveted to angle irons for stiffening. There are, as a rule, eight to twelve blades on the blast wheel, which are supported and carried by two or more cast iron spiders. The number of the latter depending upon the size of the fan. The blades are always made straight, seldom if ever being curved backward and then only very slightly right at the tip. The discharge opening may be placed in any

position or direction which is at right angles to the plane of the shaft of the machine. The casing being built in such a manner that it may be revolved around the shaft and fastened at any desired point. A great many of the larger sizes of steel plate blowers and exhausters are fitted with two discharge openings and are run by a direct connected engine.

The Sirocco Blower.

This is a type of fan used very extensively in mining, where it seems to give excellent results. The chief points of its construction are as follows:— The blades

are very numerous, with their radial measurements (relative to the diameter of the fan) very shallow, and their axial measurements very long. Their outer edges are curved forward in the direction of rotation, and the air passages between the blades are usually open at the ends toward the inflowing air. The inlet for admitting air to the fan, and the outlet for its discharge, are approximately of equal diameter to the fan itself. All of these features constitute practically a reversal of previous theory and practice in regard to fan construction, never

the less, it is claimed that the actual effect of this design is to materially increase the volume of air discharged per revolution. The sirocco fan is well adapted to high speed and therefore to electric driving.

Experiments.

The following series of experiments on Centrifugal Fans and Exhausters was conducted by the writers in the Mechanical Engineering Laboratory of the University of Illinois.

Object.

The object of the tests made on the fans and exhausters was the determination of their

capacity to move a given volume of air under conditions with respect to the pressure and size of opening of the discharge pipe. Also the determination of the power required for moving a given quantity of air under the conditions named above, and finally, the efficiencies of the fans and exhausters. From the complete tests, as outlined, were determined the most economical conditions under which certain quantities of air could be moved. In order to meet these requirements it was necssary to make accurate measurements of: first, the power required to operate the fan; second,

the volume of air delivered by the fan; third, the pressure produced and fourth, the power required. Refering to these several requirements, the object may be briefly stated as follows, for each condition.

1. How the quantity of air discharged varies with the speed.

2. How the pressure varies with the speed.

3. How the horse power varies with the speed.

Apparatus.

The arrangement of the apparatus whereby the actual measurements of the horse-power, volume of air discharged, compression and speeds were obtained in each

experiment is shown by plates I. and II. pages 21 and 22 respectively. The fans and exhauster were driven from a counter shaft, which derived its motion from a twenty five horse-power, horizontal Ball Engine (See page 20). The outlet of the fans and the intake of the exhauster was fitted with a circular galvanized iron pipe twelve feet long, the diameter of which was such as to just fit the opening. A sliding gate (See fig. 2 Plate I.) was attached to the end of the circular pipe, and by means of it the discharge opening of the fan and intake of the exhauster was varied to suit the different conditions under which

the experiment was run. A Crosby Steam Indicator was used to find the indicated horse-power. In all the experiments hand speed counters were used to obtain the R.P.M. of the engine. For obtaining the speeds of the fans and exhauster a calibrated tachometer was used when the arrangement of the fan shaft was such as to permit the tacometer belt to be run upon it, otherwise the speed was obtained with a hand speed counter.

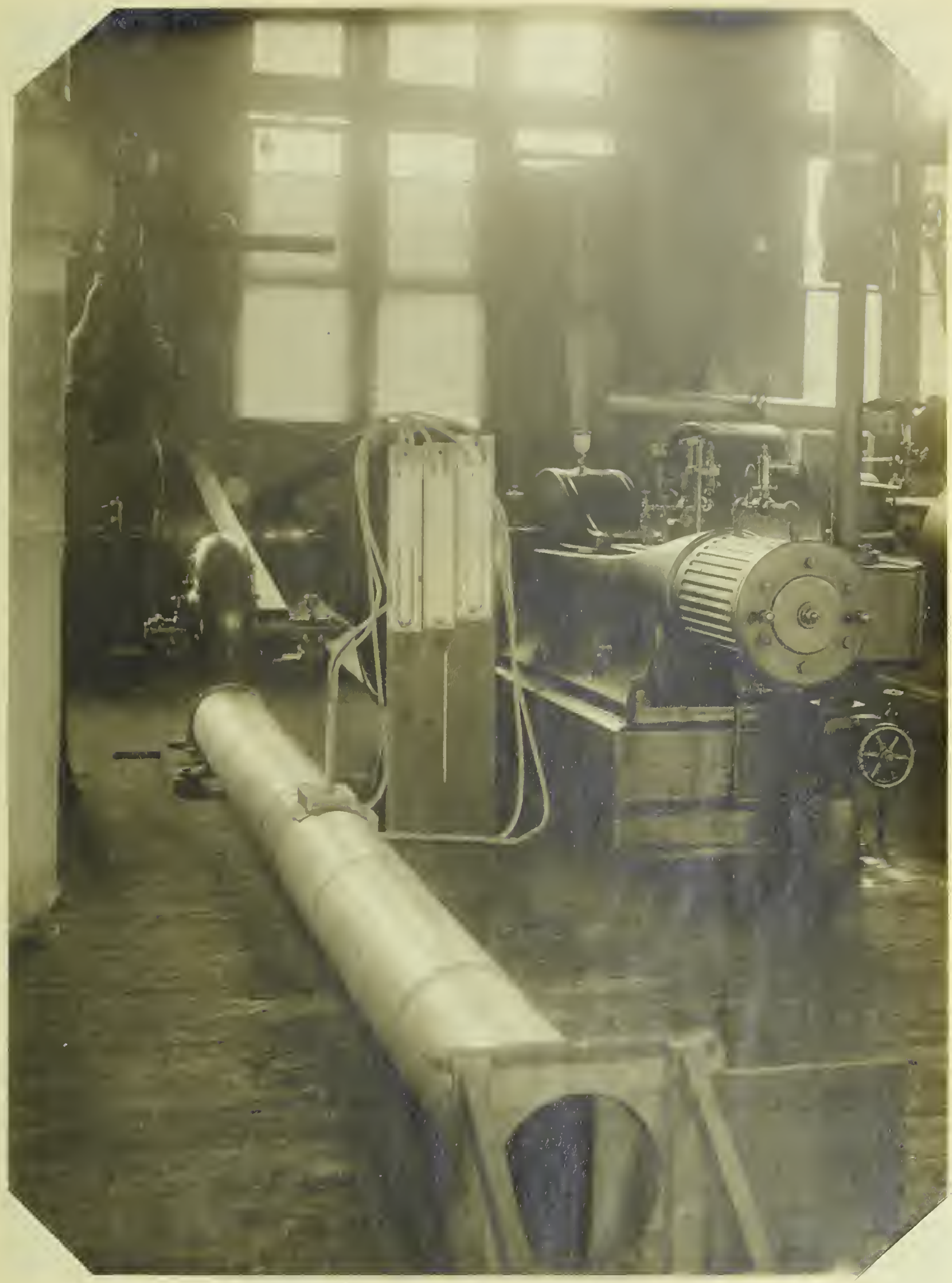
Measurements of the pressure and velocity of the air stream were taken at a section of the pipe five feet from the discharge opening of the fan and seven

seven feet from the intake opening of the exhauster. The pressure of the air was measured with a U shaped gage made from 1/4 inch glass tubing, and of such a length as would permit the registration of 14" of water. One arm of the gage was open to the atmosphere, while the other was connected by means of rubber tubing to a small pipe, or tip, soldered on-to the side of the delivery tube. The scale used for reading the height of the water column was ruled in ounces and tenths of ounces. For measuring the velocity of the air a combination of the Pitot tube and the pressure gage

was resorted to. Readings were taken at several points in the cross-section of the pipe by means of two velocity tips, each of which could be traversed over a diameter at right angles to the other. The water gage was of a similiar type and construction as was used for the pressure readings, with the exception that its scale was ruled in inches instead of ounces. The velocity tips used (See fig. 5 Plate II, page 22.) consisted of a Pitot tube and a straight tube, having a small circular guide, or side tip, glued on to the end of it. These two tubes were wired together and clamped onto a thin flat stick to give them sufficient strength. The purpose

of the guide was to eliminate the error that presents itself in the measurement of compression, owing to the fact that air flowing across the end of a plain tube causes a large amount of induction; a vacuum being often recorded when a pressure is known to exhist. One of the branches, of the U tube, of the velocity gage was connected to the Pitot tube by means of rubber tubing and the other to the tube of the side gage. (See figures 1, 2 and 3 Plate II page 22.) The pressure in the arm connected to the straight tube, or side tip, will be due to the compression of the air only, while the pressure in the arm connected with the

Pitot tube will be due to pressure and velocity combined. Hence the reading of the water gage will be the difference of these pressures, which is that due to velocity alone. The velocity tips were held in position by inserting them through suitable openings cut in small boxes which were firmly wired over the holes cut in the delivery tubes for inserting the velocity tips. The Pitot tube was placed so that it always faced the current. The U tubes and velocity tips were all made from 1/4 inch glass tubing, the small circular guides, or side tips, were made of oak, their dimensions being given in fig. 4, Plate II. page 22.



GENERAL ARRANGEMENT
OF
APPARATUS

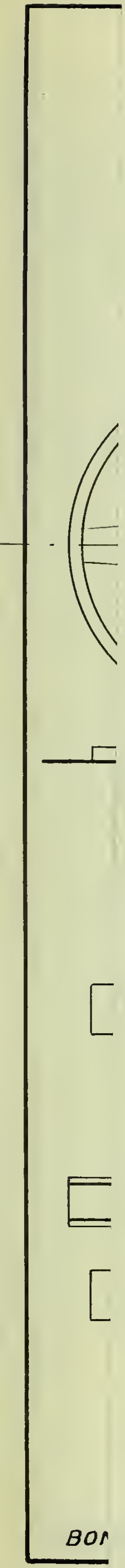
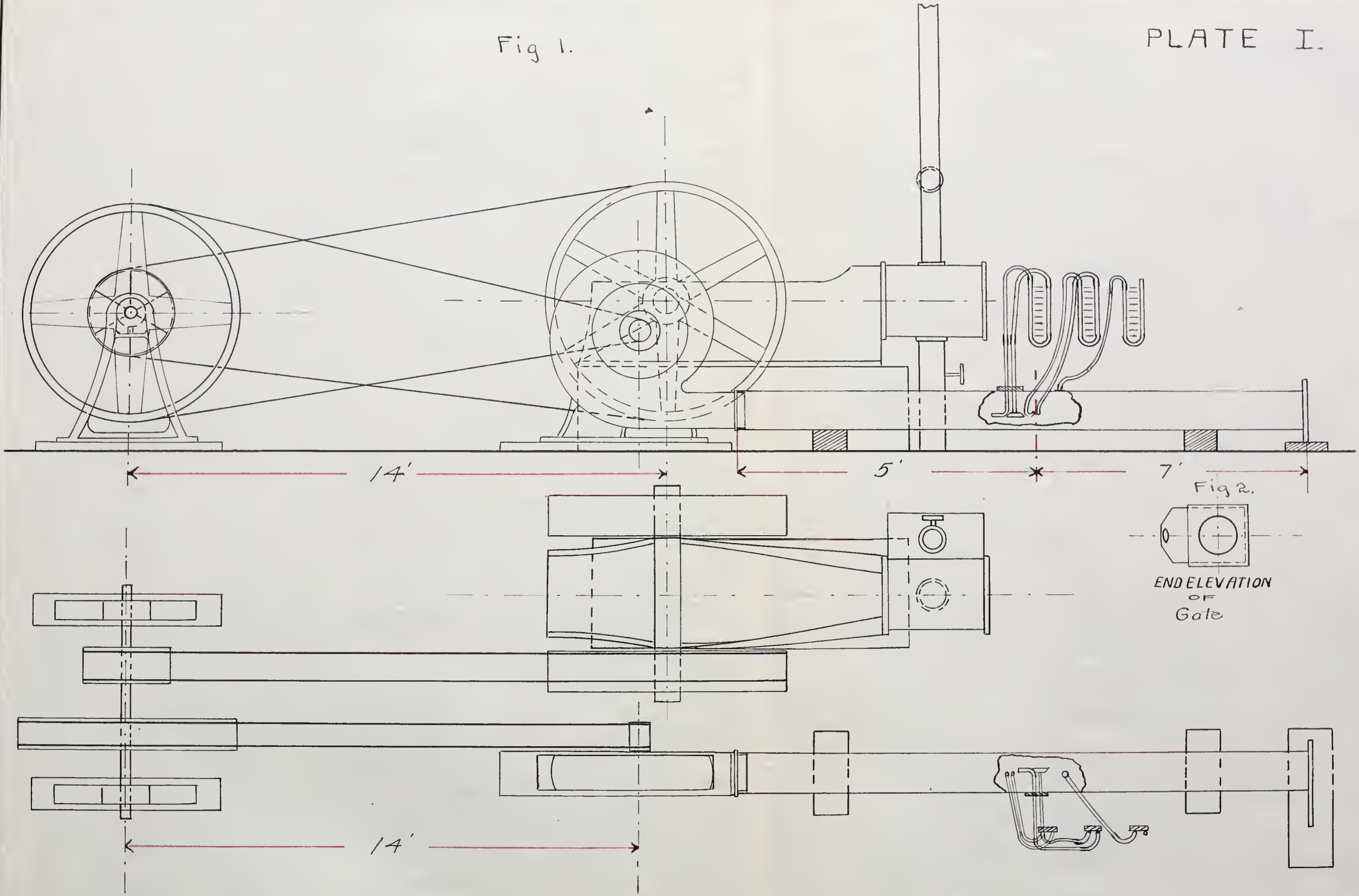


PLATE I.



FAN-TESTING APPARATUS.

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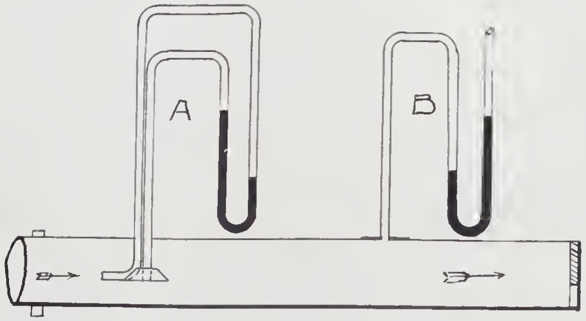
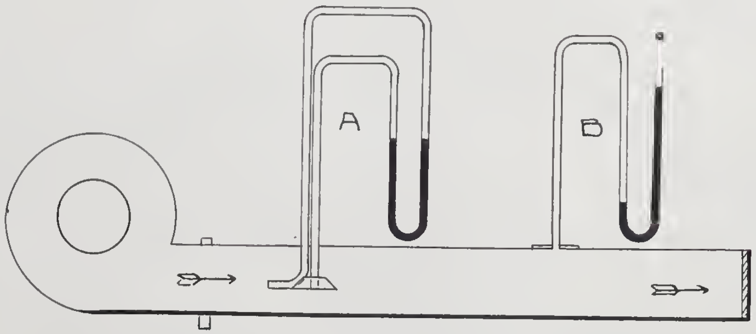
PLATE II.

FIG. 1.



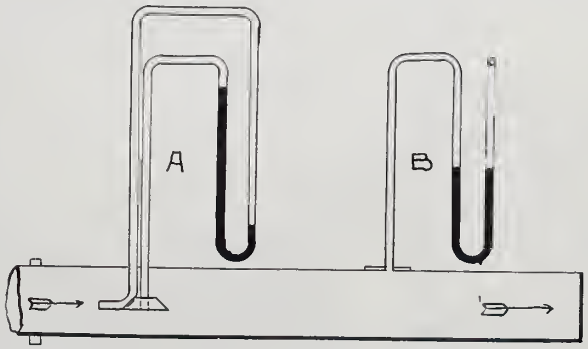
OUTLET PARTLY OPEN

FIG. 2.



OUTLET CLOSED

FIG. 3



OUTLET FULL OPEN

A VELOCITY GAGE
B PRESSURE GAGE

FIG. 4.
VELOCITY TIP
SCALE 1/4" = 1"

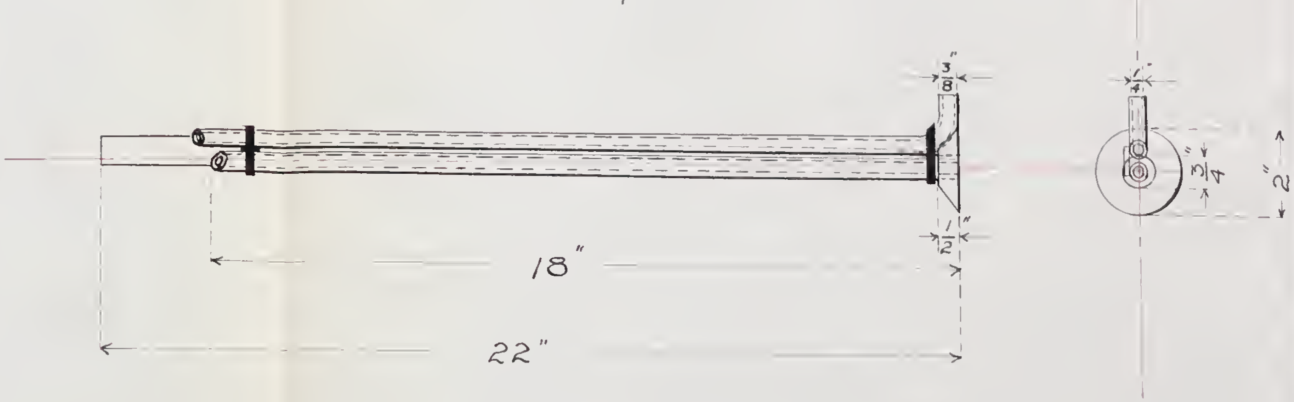
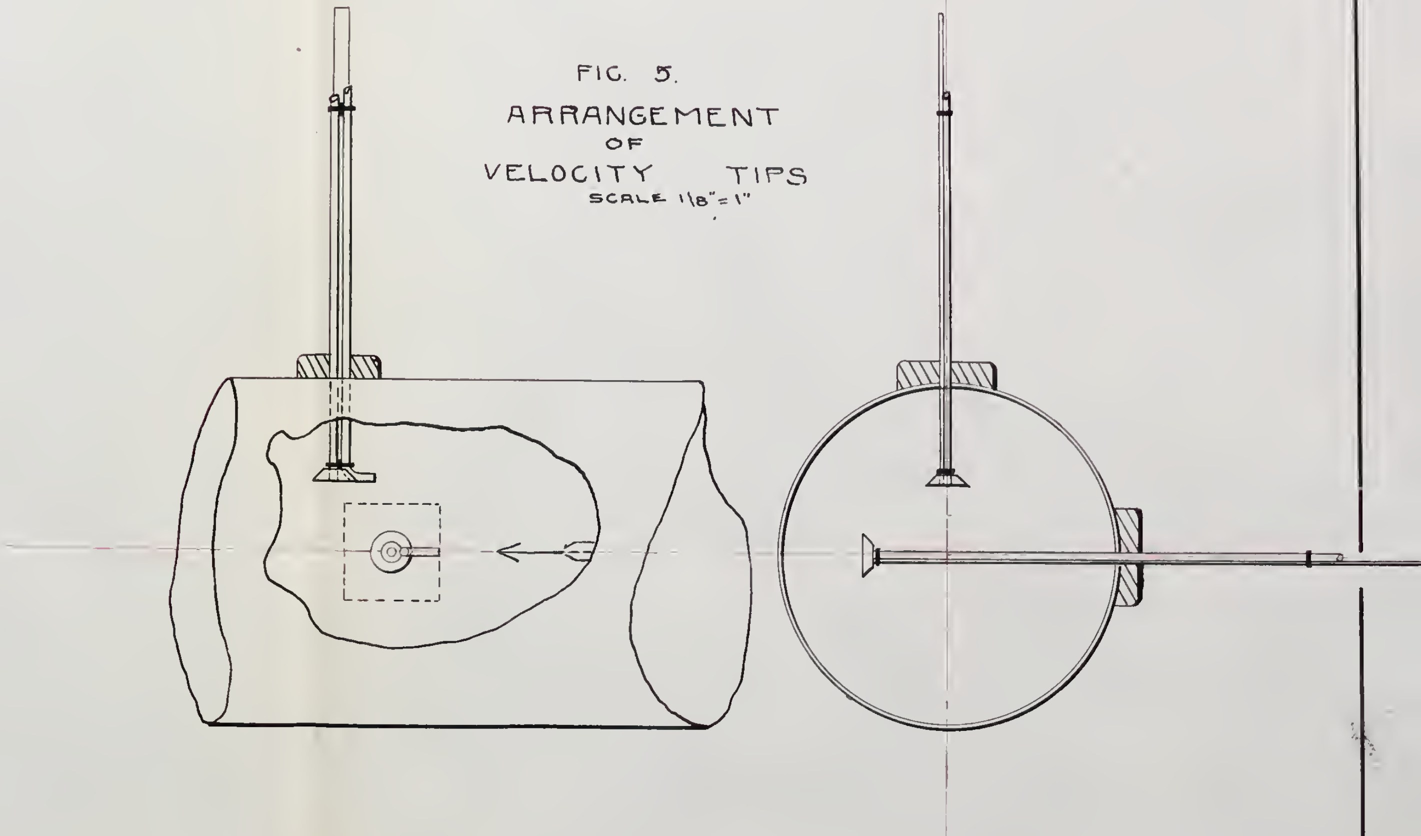


FIG. 5.
ARRANGEMENT OF VELOCITY TIPS
SCALE 1/8" = 1"



APPARATUS FOR MEASURING
PRESSURE AND VELOCITY

BONNELL AND LUNDAHL

Method.

General Outline of Tests: In each set of experiments the quantity of air passed was varied, thus producing a corresponding change in the pressure and power required to drive the fan. This was easily and quickly effected by throttling the flow of air in the delivery tube by means of an air gate placed at the end of the tube. In each experiment, for every speed run, the air was made to pass through this gate successively at full, 1/4, 1/2, 3/4 and zero gate opening, except in the case of the No. 1 Sturtevant Blower. Its delivery tube being so small that full 1/3, 2/3 and zero gate openings were used.

From eight to twelve speeds were run for each gate-opening, they lying between those for which the fan was designed to run.

Speed.– The governor of the engine used to drive the fan was blocked out and the different speeds were obtained by means of a throttling valve placed in the steam-pipe.

Horse-power.– A Crosby Steam Indicator was used for taking indicator cards by means of which the I. H. P. was determined. A friction test was run on the engine and counter shaft and a friction curve was plotted for the various speeds; by the use of it the H.P.

consumed by the engine and counter shaft could be found for any speed. Subtracting this result from the I. H. P., at the same speed, gave the actual H. P. consumed by the fan alone.

Order of taking readings.— Corresponding to the various speeds, readings were taken for gate openings in the following order; full, 1/4, 1/2, 3/4 and zero. The gate was first set at full opening and the speed of the fan brought up to the desired point, where it was run for a short time to assure its remaining constant, then the R. P. M. of the fan and engine were taken simultaneously, after which one

man took the indicator card, while the other read the pressure and velocity gages as quickly as possible: these readings were checked by reading the gages twice. The remaining gate openings were then taken in the order named. The velocity gages were marked at points corresponding to the distances to which they would have to be inserted into the delivery tube, to correspond to the centers of the equal areas into which the cross section of the tube was supposed to be divided, in order that they might be the more quickly manipulated and read. The horizontal velocity gage was always read first

then the vertical velocity gage after which the pressure was noted.

Temperature and Barometer readings.— The average temperature was determined by placing a thermometer at the discharge opening and taking a reading every thirty minutes. The barometer readings recorded are the averages for the days on which the tests were run.

Calculations.

Actual Horse-power to Drive the Fan.— The measurement of the total horse-power required to operate the fan was obtained from indicator diagrams taken as previously explained. This indicated horse power, however, shows not the power applied to the fan,

but the power applied to the piston of the engine. To find the actual H. P. used to drive the fan, this I. H. P. was decreased by the amount of the power absorbed by the friction of the engine and counter shaft. A friction test was run on the engine and counter shaft at a wide range of speeds and the results plotted. From the curve thus obtained could be determined the friction H. P. for any speed. Subtracting this result from the I. H. P. taken at the same speed the actual H. P. to drive the fan was obtained.

Pressure. – The pressure was read directly from the gage in ounces,

(see description of pressure gage, page)
thus eliminating the calculation of each pressure separately, if the readings had been taken in inches of water. The calculation for reducing inches of water to ounces of pressure, in order to rule the scale in ounces was made as follows.–

1 lb. press. corresponds to 2.304 ft. of water.
16 oz " " " " 27.648 in. " "
1 oz " " " " 1.727 " " "

this length in inches (1.727") corresponding to one ounce of pressure was subdivided into tenths and the scale ruled accordingly.

Velocity.– The calculation of the velocity was made according to the formula deduced by Hemm

and Gilbert. in Vol. 173, of the P. I. C. E.. Suppose the air to be flowing directly against the mouth of a tube which is connected to a gage for the purpose of measuring the pressure produced by this velocity. The pressure h, in feet of air due to a velocity of v ft. pr. sec. is $h = \frac{v^2}{2g}$ (1).

If h be measured in inches of water, as it would be measured in practice, regard must be had to the relative densities of air and water at the time of the experiment.

Let h = pressure measured as a column of air in feet.

Let i = the corresponding pressure measured in inches of water.

T = the absolute temperature of the air in degrees Fah.

h_b = height of the barometer in inches of mercury.

Then PV being equal to 53.2 T for one pound of air, when P, the pressure of the atmosphere, would be measured by a barometer, the following numerical relation is found between h and i:—

$$h = 3.91\frac{i \times T}{h_b} \qquad (2).$$

$$\text{H.P. of fan} = \frac{V \times i}{6.352} \qquad (3).$$

This equation is deduced under the heading of theoretical horse-power. Substituting the value h in equation (3)

$$i = \frac{V^2 h_b}{2\,51.7T} \qquad (4)$$

This formula gives the reading of the water gage due to velocity V

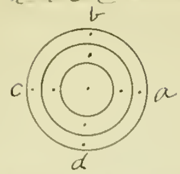
for any given atmospheric condition of barometer and temperature.

When $T = 60°F$ and $h_0 = 30''$ mercury

$$i = \frac{V^2}{4370} \text{ or } V = \sqrt{i \times 4370}.$$

In applying this formula to obtain our results the average values of the temperature, barometer and i readings were used.

Volume.— The volume of air delivered was found by obtaining the average velocity of the air in the discharge pipe and multiplying it by the area in sq. ft. of the pipe. This average velocity was obtained as follows:- the discharge pipe, in each case, was divided into a number of equal areas and four readings

taken in each area (as at a, b, c and d 

). The mean of these readings was taken as the velocity of that area. The velocities of the remaining areas were found in the same manner and then the average of the velocities of all the areas was taken as the correct velocity of the air in the delivery tube. With the average velocity known the volume in cu. ft. pr. sec. was computed by multiplying the velocity in ft. pr. sec. by the area of a cross section of the discharge pipe in sq. ft. The amount of air discharged per H. P. per. sec. was obtained by dividing the discharge in cu. ft. per. sec. by the H. P.

required to drive the fan at that velocity.

Theoretical horse power:– The work done by the fan in ft. lbs. per lb. of air entering the fan is.– Volume of air in cu. ft. per lb. × the increase in pressure in lbs. per sq. foot, and where,

v = Vol. of air entering fan in cu. ft. pr. min.

i = Press. in inches of water. A pressure of 1 inch of water being equivalent to 5.2 lbs. pr. sq. ft.

$$\text{Theoretical H.P.} = \frac{v \times 5.2 i}{33000} = \frac{v \times i}{6352}.$$

Since 1 ounce of pressure = 9 lbs pr. sq. ft. the above formula reduces to the form,

$$\text{Theoretical H.P.} = \frac{v \times oz}{3666.66}.$$

Efficiency:– The efficiencies of

the fans and exhauster was found by dividing the theoretical H.P. by the actual H.P. required to drive the fans.

EXPERIMENT NO. 1

Buffalo Volume Blower No. 8.

See Plate III. p. 40:– The general structural details of this blower are as follows:– To the solid (cast iron) outer peripherial shell, which carries likewise the discharge orifice, are securely bolted two side plates, in which are formed the inlets. The pedestals carrying the standard oil ring bearings are bolted to these side plates. The blower is built with only one driving pulley. Its blast wheel is built with five wrought iron, radial spokes, bent backward at their outer ends, each carrying a blade which continues this backward curvature of the spokes to

to their outer circumferences. thus making a total backward curvature of 3 inches. Conical side plates are riveted to the spokes and extend entirely around the wheel thus making it very rigid.

Table of Dimensions:—

Height Total	48"
Length " "	47.5"
Width " "	40."
Diam. of Pulley	8.5"
Width " "	7.5"
Diam. of Blast Wheel	28"
Width " " " "	11"
No of Blades	5
Size " " "	11"x9"
Area of " "	88 sq. in.
Diam. of Outlet (outside of flange)	16.5"

Diam. of Outlet (inside of pipe flange)	13"
Area " " "	132.7 sq. in.
Diam. of Inlet. (pulley side)	13.5"
Area " " " " "	86.4 sq. in.

The area of the pulley was subtracted as it obstructed the opening.

Diam. of Inlet. (opposite side)	13.5"
Area " "	114 sq. in.
Ratio $\frac{\text{Area of Inlet}}{\text{Area of Outlet}}$ =	1.56
Diam. of Shaft.	1.75"
Length of Bearings	9"

Temperature and Barometer Readings.

Barometer (average)	29.2"
Temperature	80.8°F

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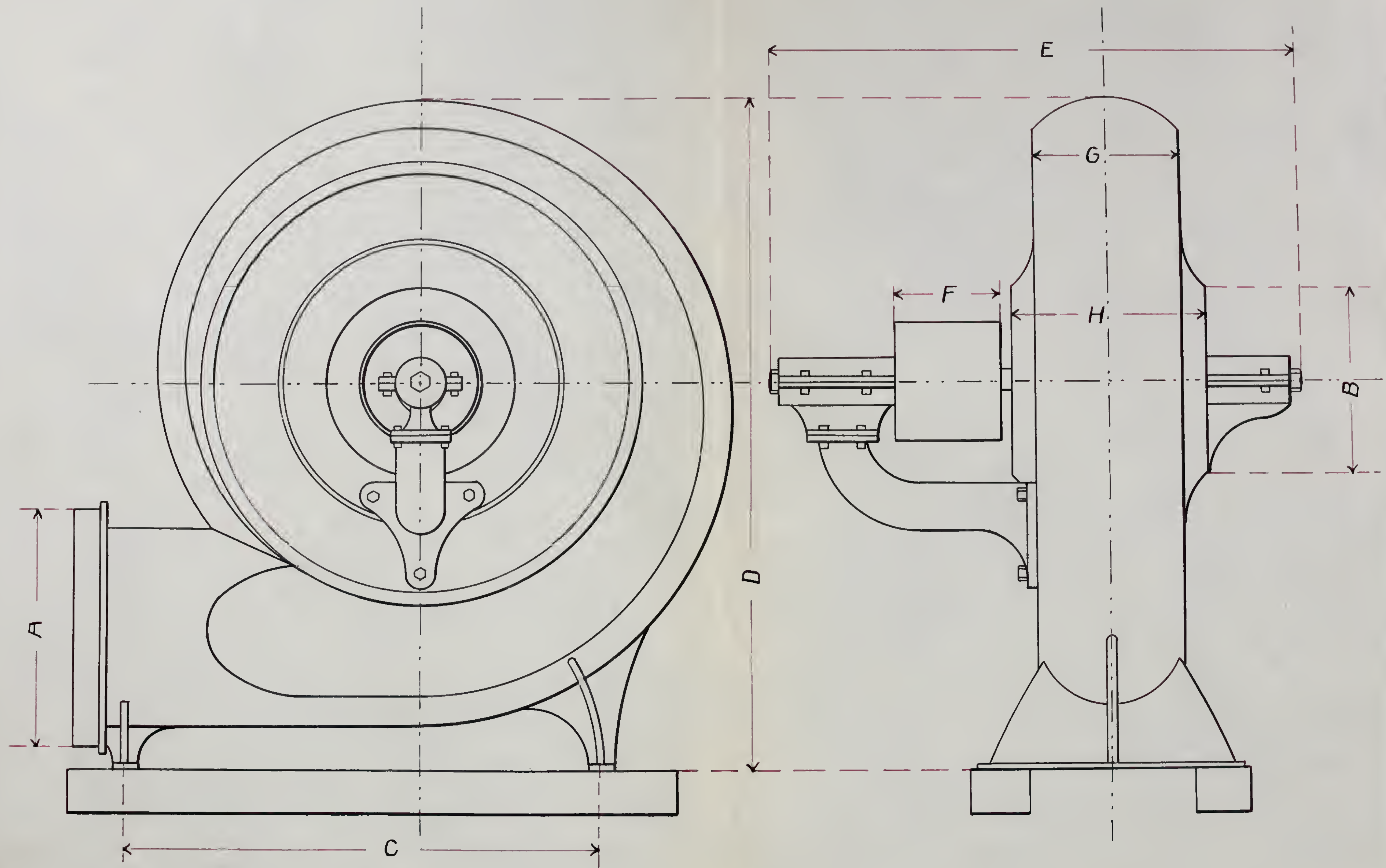
PLATE III.

BUFFALO VOLUME BLOWER NO 8.



BONNELL AND LUNDAHL

TABLE I.

DATA AND RESULTS FOR BUFFALO BLOWER NO 8.

FULL OPENING OF DISCHARGE

R.P.M. FAN	R.P.M. ENG.	PRESSURE OZ.PER.SQ.IN.	VEL. HEAD IN. WATER	VEL. OF AIR FT. PER. SEC.	AIR DISCH. CU.FT. PER.SEC.	VEL. FAN TIPS FT. PER. SEC.	H.P. TOTAL	H.P. TO DRIVE FAN	H.P. THEORETICAL	CU.FT. AIR DISCH PER.H.P. PER.SEC.	EFFICIENCY %
630	54	.05	.577	51.2	74	81	2.4	2.1	.06	35.2	2.9
795	68	.08	.770	59.2	85	99	3.5	3.2	.11	26.6	3.5
990	85	.11	1.20	74.0	107	122	6.4	5.9	.19	18.0	3.3
1185	99	.14	1.62	86.0	124	145	9.3	8.7	.28	14.1	3.3
1380	117	.15	2.22	101.	146	168	14.4	13.7	.36	10.6	2.6
1650	140	.29	3.16	120.	173	198	23.2	22.2	.57	7.8	2.6
1770	148	.35	3.52	140.	202	214	26.2	26.1	.91	7.7	3.7

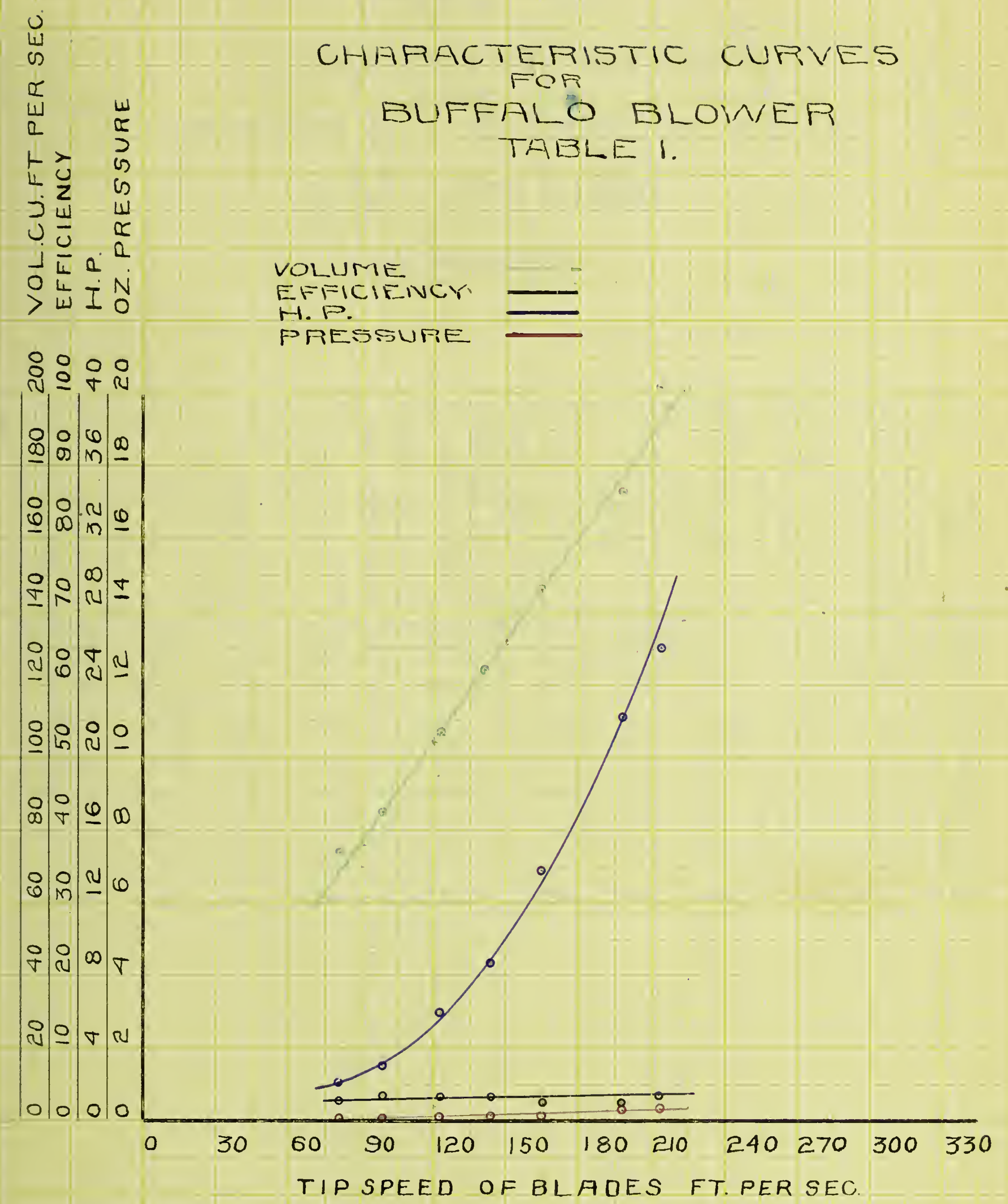

CHARACTERISTIC CURVES
FOR
BUFFALO BLOWER
TABLE I.
VOL. CU. FT PER SEC.
EFFICIENCY
H.P.
OZ. PRESSURE
VOLUME
EFFICIENCY
H. P.
PRESSURE
0 20 40 60 80 100 120 140 160 180 200
0 10 20 30 40 50 60 70 80 90 100
0 4 8 12 16 20 24 28 32 36 40
0 2 4 6 8 10 12 14 16 18 20
0 30 60 90 120 150 180 210 240 270 300 330
TIP SPEED OF BLADES FT. PER SEC.

TABLE 2.

DATA AND RESULTS FOR BUFFALO BLOWER NO 8.

3/4 OPENING OF DISCHARGE

R.P.M. FAN	R.P.M. ENG.	PRESSURE OZ. PER. SQ. IN.	VEL. HEAD IN. WATER	VEL. OF AIR FT. PER. SEC.	AIR DISCH CU. FT. PER. SEC.	VEL FAN TIPS FT. PER. SEC.	H.P. TOTAL	H.P. TO DRIVE FAN	H.P. THEORETICAL	CU. FT. AIR DISCH. PER. H.P. PER. SEC.	EFFICIENCY %
652	54	.45	.35	39.6	56.2	79	2.0	1.7	.41	33.1	24.8
815	67	.66	.50	47.7	68.7	99	3.4	3.1	.74	22.5	24.3
1000	85	1.08	.80	60.5	87.1	122	6.1	5.6	1.54	15.4	27.3
1205	100	1.42	1.13	71.8	98.7	147	9.1	8.6	2.29	11.5	26.6
1378	116	1.73	1.39	79.5	114.5	168	13.1	12.4	3.24	9.2	26.0
1575	137	2.42	1.87	92.5	133.2	193	26.7	25.7	5.29	5.2	20.9
1775	156	3.40	2.60	107.0	154.0	217	26.0	24.8	8.57	6.2	34.4
1865	158	3.66	2.66	110.0	158.5	228	27.4	26.2	9.50	6.1	37.8

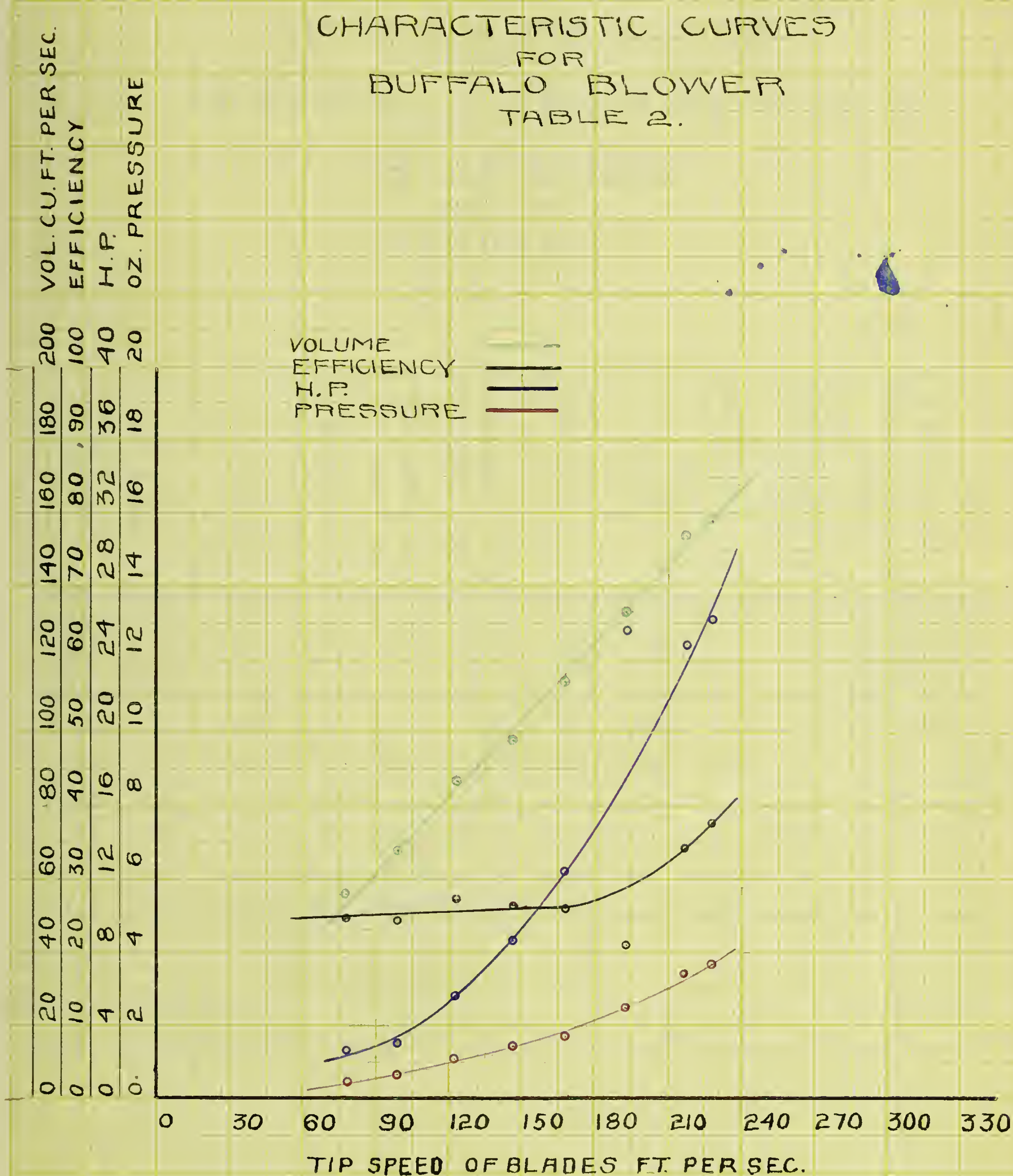

CHARACTERISTIC CURVES
FOR
BUFFALO BLOWER
TABLE 2.
VOL. CU. FT. PER SEC.
EFFICIENCY
H.P.
OZ. PRESSURE
VOLUME
EFFICIENCY
H.P.
PRESSURE
0 20 40 60 80 100 120 140 160 180 200
0 10 20 30 40 50 60 70 80 90 100
0 4 8 12 16 20 24 28 32 36 40
0 2 4 6 8 10 12 14 16 18 20
0 30 60 90 120 150 180 210 240 270 300 330
TIP SPEED OF BLADES FT. PER SEC.

TABLE 3.

DATA AND RESULTS FOR BUFFALO BLOWER NO 8.

1/2 OPENING OF DISCHARGE

R.P.M. FAN	R.P.M ENG.	PRESSURE OZ.PER.SQ.IN	VEL. HEAD IN. WATER	VEL. OF AIR FT. PER. SEC.	AIR DISCH. CU. FT. PER. SEC.	VEL. FAN TIPS FT. PER. SEC.	H.P. TOTAL	H.P. TO DRIVE FAN	H.P. THEORETICAL	CU. FT. AIR DISCH. PER. H.P. PER SEC	EFFICIENCY o/o.
660	55	.75	.19	29.6	42.6	80	1.7	1.3	.52	32.3	39.6
815	68	1.15	.27	34.8	50.1	99	2.6	2.3	.95	21.6	40.8
1015	85	1.92	.42	43.7	63.0	124	4.6	4.2	1.98	15.1	47.5
1220	100	2.62	.61	52.5	75.5	149	7.0	6.5	3.25	11.7	50.2
1360	110	2.96	.65	54.5	78.5	166	9.6	9.0	3.81	8.7	42.3
1560	132	4.20	.97	66.5	95.7	191	15.0	14.1	6.60	6.8	46.8
1765	150	5.56	1.27	76.0	109.3	217	20.1	19.2	9.88	5.7	51.5
2000	170	7.20	1.69	87.6	126.2	244	27.5	26.0	14.90	4.8	58.4
2065	188	8.40	1.88	92.5	132.5	252	36.0	32.8	18.25	4.1	51.8

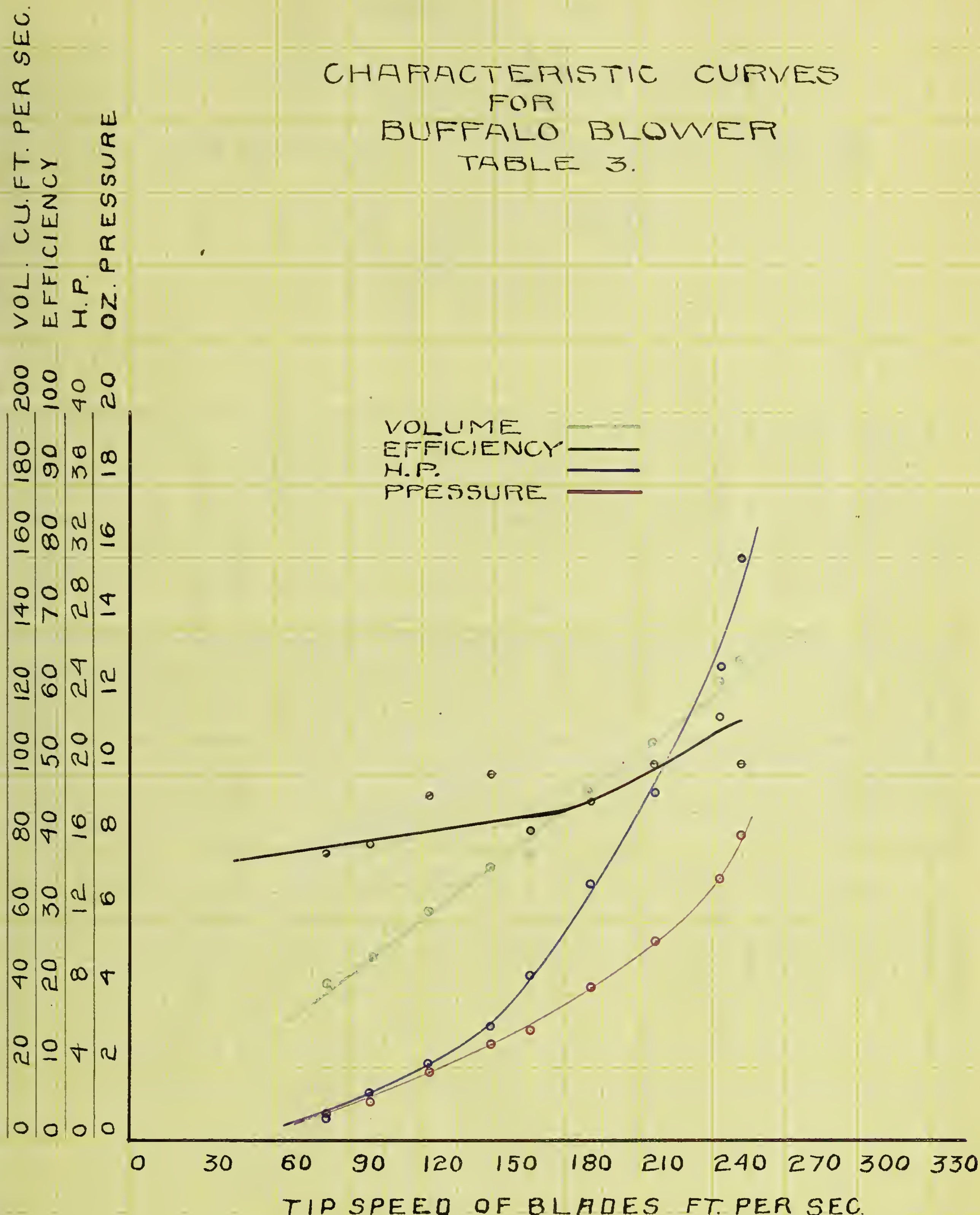

CHARACTERISTIC CURVES
FOR
BUFFALO BLOWER
TABLE 3.
VOL. CU. FT. PER SEC.
EFFICIENCY
H.P.
OZ. PRESSURE
0 20 40 60 80 100 120 140 160 180 200
0 10 20 30 40 50 60 70 80 90 100
0 4 8 12 16 20 24 28 32 36 40
0 2 4 6 8 10 12 14 16 18 20
VOLUME
EFFICIENCY
H.P.
PPESSURE
0 30 60 90 120 150 180 210 240 270 300 330
TIP SPEED OF BLADES FT. PER SEC.

TABLE 4.

DATA AND RESULTS FOR BUFFALO BLOWER NO 8.

1/4 OPENING OF DISCHARGE

R.P.M. FAN.	R.P.M. ENG.	PRESSURE OZ. PER SQ. IN.	VEL. HEAD IN WATER	VEL. OF AIR FT. PER. SEC.	AIR DISCH. CU. FT. PER. SEC.	VEL. FAN TIPS FT. PER. SEC.	H.P. TOTAL	H.P. TO DRIVE FAN	H.P. THEORETICAL	CU. FT. AIR DISCH. PER. HP. PER SEC.	EFFICIENCY %
635	53	1.20	.06	16.9	24.4	77	1.4	1.2	.40	20.0	48.7
815	68	1.57	.10	21.4	30.8	99	1.9	1.6	.79	19.4	49.0
1015	85	2.28	.12	23.0	33.2	124	3.1	2.5	1.24	13.1	48.7
1205	100	3.30	.16	26.0	37.4	144	4.8	4.3	2.05	8.7	48.0
1360	112	4.30	.20	28.2	40.3	166	6.6	5.9	2.84	5.9	47.8
1560	132	5.55	.26	34.6	49.8	191	10.0	9.1	4.54	5.5	50.0
1770	153	7.90	.35	39.4	56.2	216	14.8	13.5	7.34	4.1	54.0
2000	168	9.50	.41	42.8	61.7	244	18.8	17.4	9.62	3.6	55.4
2130	188	11.60	.50	48.0	69.0	260	21.2	19.4	13.10	3.6	67.5

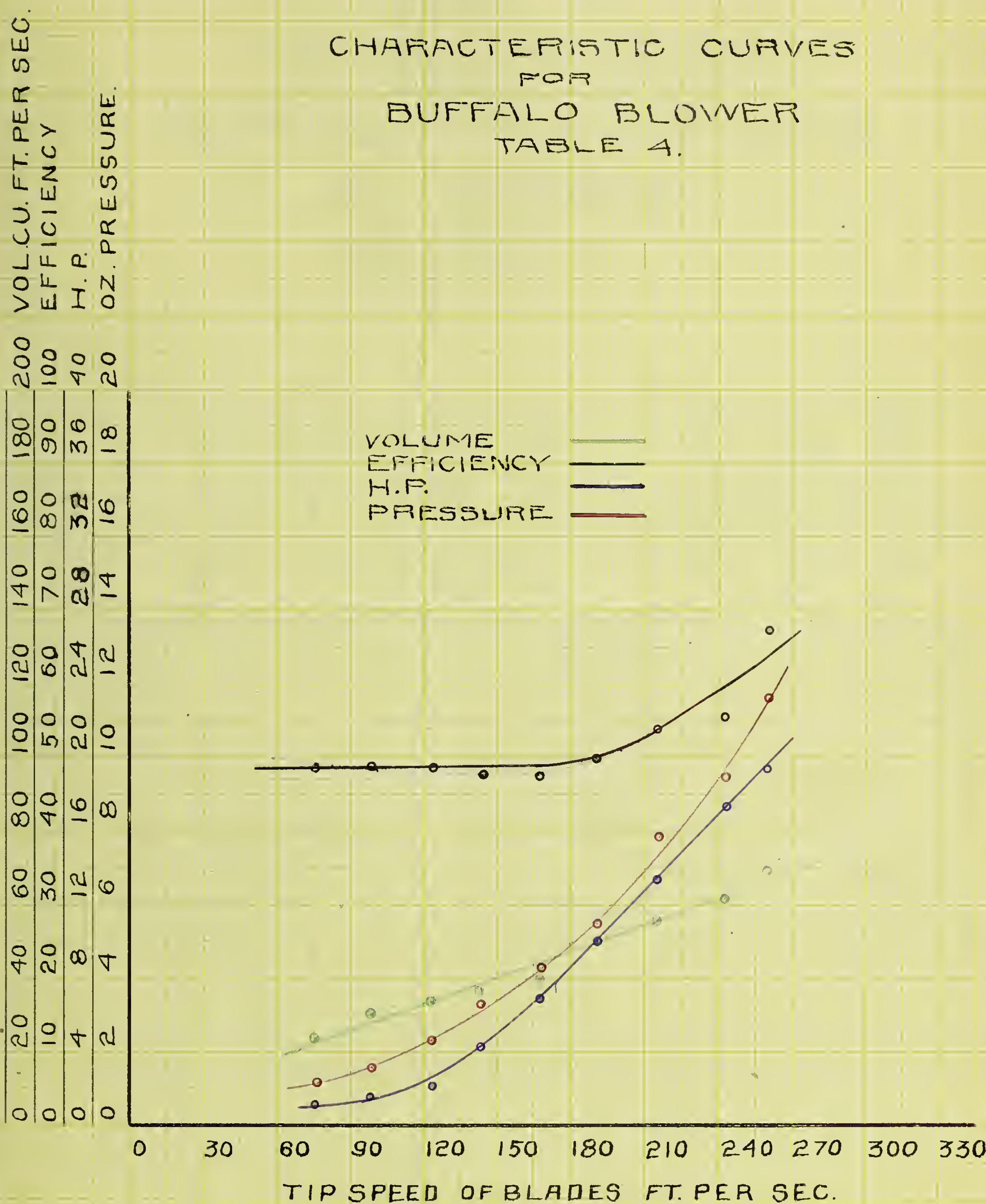
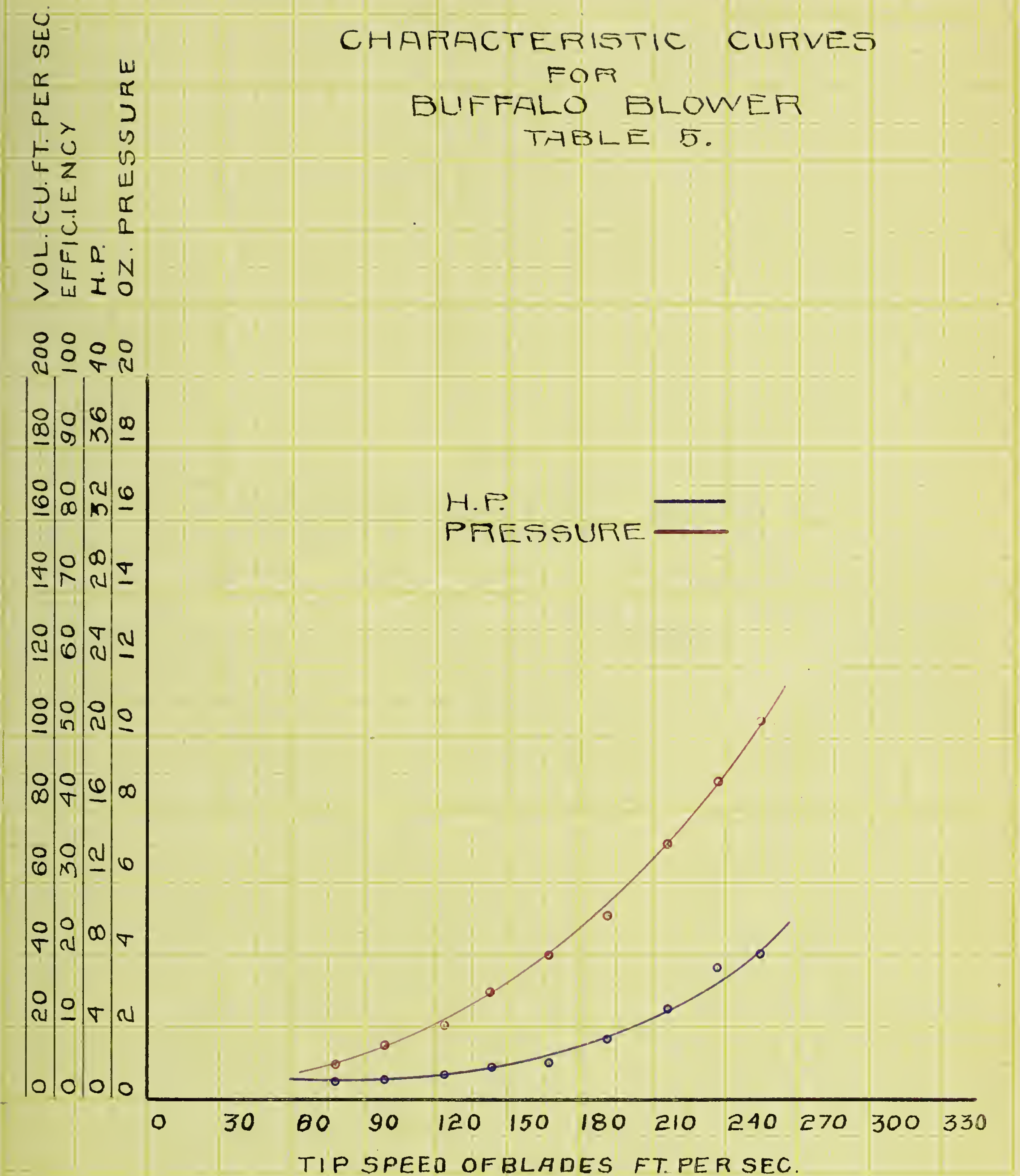

CHARACTERISTIC CURVES
FOR
BUFFALO BLOWER
TABLE 4.
VOL. CU. FT. PER SEC.
EFFICIENCY
H. P.
OZ. PRESSURE.
VOLUME
EFFICIENCY
H.P.
PRESSURE
0 20 40 60 80 100 120 140 160 180 200
0 10 20 30 40 50 60 70 80 90 100
0 4 8 12 16 20 24 28 32 36 40
0 2 4 6 8 10 12 14 16 18 20
0 30 60 90 120 150 180 210 240 270 300 330
TIP SPEED OF BLADES FT. PER SEC.

TABLE 5.

DATA AND RESULTS FOR BUFFALO BLOWER NO 8.

O OPENING OF DISCHARGE

R.P.M. FAN.	R.P.M. ENG.	PRESSURE OZ. PER SQ. IN	VEL. HEAD IN. WATER	VEL. OF AIR FT. PER. SEC.	AIR DISCH. CU. FT. PER. SEC.	VEL. FAN TIPS FT. PER. SEC.	H.P. TOTAL	H.P. TO DRIVE FAN	H.P. THEORETICAL	CU. FT. AIR DISCH. PER. H.P. PER. SEC.	EFFICIENCY %
640	53	1.00	0	0	0	78	.87	1.01	0	0	0
825	68	1.50	0	0	0	99	1.50	1.15	0	0	0
1015	85	2.17	0	0	0	124	1.38	1.38	0	0	0
1178	98	3.00	0	0	0	143	2.33	1.78	0	0	0
1378	112	4.00	0	0	0	168	2.74	2.10	0	0	0
1560	130	5.20	0	0	0	191	4.50	3.65	0	0	0
1775	150	7.10	0	0	0	217	6.22	5.12	0	0	0
1950	164	8.70	0	0	0	238	8.76	7.41	0	0	0
2115	184	10.50	0	0	0	258	9.72	8.07	0	0	0


CHARACTERISTIC CURVES
FOR
BUFFALO BLOWER
TABLE 5.
H.P.
PRESSURE
VOL. CU. FT. PER SEC.
EFFICIENCY
H.P.
OZ. PRESSURE
200 100 40 20
180 90 36 18
160 80 32 16
140 70 28 14
120 60 24 12
100 50 20 10
80 40 16 8
60 30 12 6
40 20 8 4
20 10 4 2
0 0 0 0
0 30 60 90 120 150 180 210 240 270 300 330
TIP SPEED OF BLADES FT. PER SEC.

EXPERIMENT NO. 2

Buffalo Pressure Blower No. 7.

The general appearance of this blower is the same as that of No. 8 (See Plate III, page 40.) except that it has two driving pulleys and that its blast wheel is built with ten blades, five large and five small ones. The small blades are about one third the size of the large ones, between which they are placed, being riveted to the outer conical rim of the blast wheel.

Table of Dimensions:—

Height Total	33.5"
Length " "	34"
Width " "	30.75"
Diam. of Pulleys	5"

Face of Pulleys	$4\frac{5}{8}''$
Diam. of Shaft	$1\frac{3}{8}''$
Diam. of Blast Wheel	$17\frac{1}{4}''$
Width of " " at { Center	$5\frac{3}{8}''$
Width of " " at { Circ.	$2\frac{1}{4}''$
No. of Blades { Long	5
No. of Blades { Short	5
Area of Blades	11.7 sq. in.
Diam. of Discharge Opening	$6\frac{7}{8}''$
Area " " " "	$37\frac{1}{8}$ sq. in.
Diam. of Inlets	$9''$
Area " " "	127.24 sq. in.
Ratio $\frac{\text{Inlet Area}}{\text{Outlet Area}}$	2.3

The area of the pulleys were subtracted from the inlet area as they obstructed the openings.

Temperature and Barometer Readings.

Barometer (average)	$29.3''$
Temperature " "	$79\frac{1}{4}°$ F.

TABLE 6.

DATA AND RESULTS FOR BUFFALO BLOWER NO 7.

FULL OPENING OF DISCHARGE

R.P.M. FAN	P.P.M ENG.	PRESSURE OZ. PER. SQ. IN.	VEL. HEAD IN. WATER	VEL. OF AIR FT. PER. SEC.	AIR DISCH. CU. FT. PER. SEC.	VEL. FAN TIPS FT. PER SEC.	H.P. TOTAL	H.P. TO DRIVE FAN	H.P. THEORETICAL	CU. FT. AIR DISCH. PER H.P. PER SEC.	EFF. 0/0.
1306	52	.10	1.14	72.8	23.9	100	2.00	1.33	.039	17.9	2.9
1440	54	.15	1.33	79.4	26.0	110	2.10	1.41	.064	18.4	4.5
1520	58	.20	1.44	80.9	26.6	116	2.34	1.60	.087	16.7	5.4
1620	62	.20	1.55	83.9	27.5	123	2.70	1.90	.090	14.4	4.7
1732	70	.20	1.86	91.8	30.1	132	3.31	2.42	.098	12.5	4.1
1816	72	.20	1.90	93.1	31.0	139	3.45	2.55	.100	11.1	3.9
1946	75	.20	2.25	100.5	32.0	149	4.12	3.17	.110	9.6	3.2
2024	78	.30	2.43	105.1	33.2	154	4.53	3.56	.154	9.7	4.6
2090	80	.25	2.67	109.8	33.5	160	4.93	3.89	.138	8.7	3.6
2280	89	.30	3.15	119.8	39.5	174	5.93	4.82	.195	8.9	4.1
2600	96	.35	4.22	138.8	45.6	199	8.18	6.98	.260	6.5	3.7

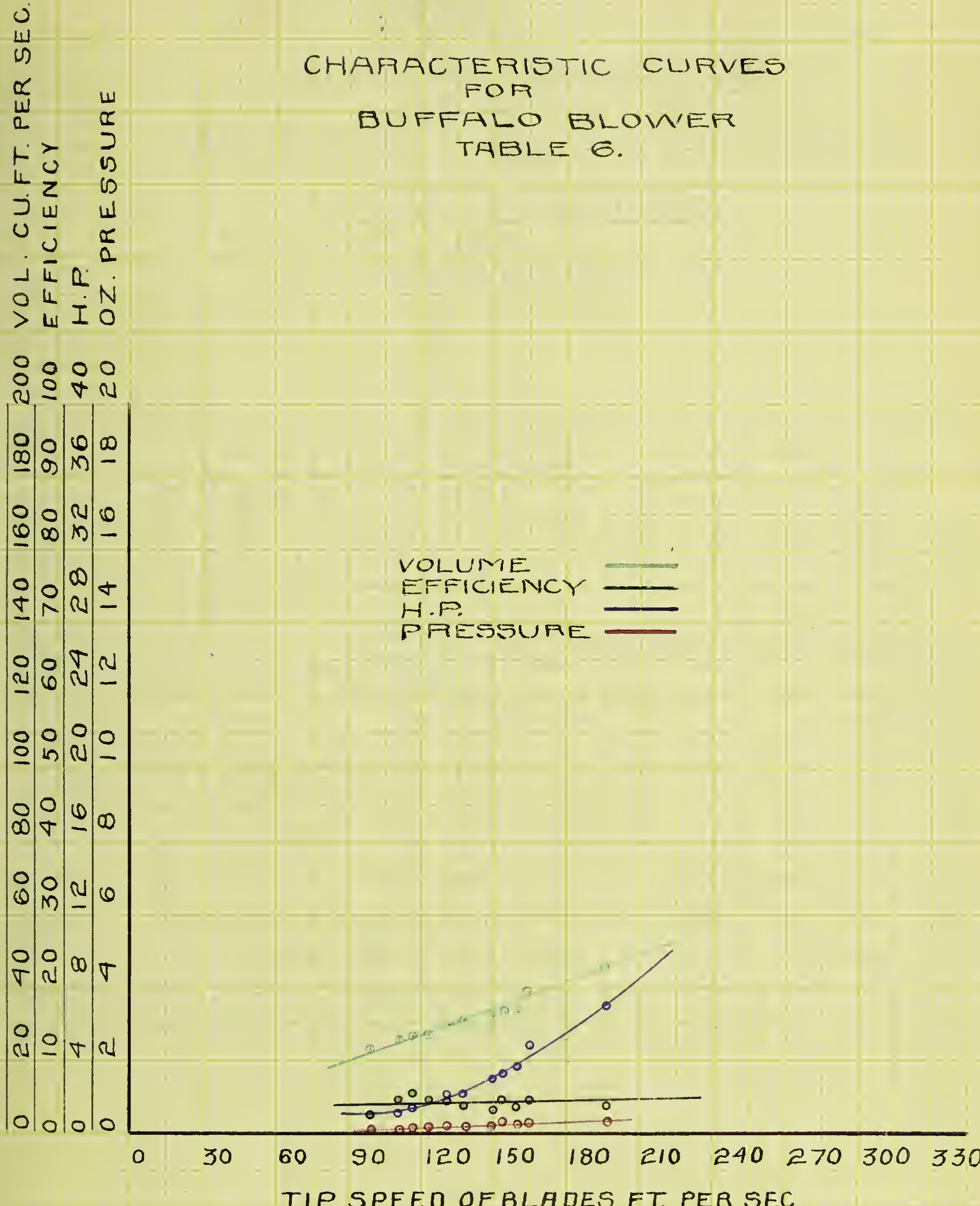

CHARACTERISTIC CURVES
FOR
BUFFALO BLOWER
TABLE 6.
VOL. CU. FT. PER SEC.
EFFICIENCY
H.P.
OZ. PRESSURE
200 100 40 20
180 90 36 18
160 80 32 16
140 70 28 14
120 60 24 12
100 50 20 10
80 40 16 8
60 30 12 6
40 20 8 4
20 10 4 2
0 0 0 0
VOLUME
EFFICIENCY
H.P.
PRESSURE
0 30 60 90 120 150 180 210 240 270 300 330
TIP SPEED OF BLADES FT. PER SEC.

TABLE 7.

DATA AND RESULTS FOR BUFFALO BLOWER NO 7.

3/4 OPENING OF DISCHARGE

R.P.M. FAN	R.P.M. ENG.	PRESSURE OZ. PER. SQ. IN.	VEL. HEAD IN. WATER	VEL. OF AIR FT. PER SEC.	AIR DISCH. CU. FT. PER. SEC.	VEL. FAN TIPS FT. PER. SEC.	H.P. TOTAL	H.P. TO DRIVE FAN	H.P. THEORETICAL	CU. FT. AIR DISCH. PER. H.P. PER. SEC.	EFF. 0/0.
1249	35	.60	.60	52.7	17.3	96.0	1.36	.90	.17	19.2	18.2
1470	56	.80	.83	61.7	20.2	112.0	2.33	1.61	.26	17.6	16.4
1532	60	.95	.88	63.6	20.8	117.0	2.09	1.32	.18	15.8	23.3
1580	62	.99	.95	66.0	21.6	121.0	2.38	1.60	.34	13.6	21.1
1732	64	1.00	1.15	72.5	23.8	132.0	2.75	1.93	.42	13.0	21.6
1814	70	1.20	1.25	75.3	24.6	138.0	3.05	2.18	.49	11.3	22.2
1920	76	1.40	1.37	79.2	25.1	146.0	3.41	2.45	.56	9.9	22.6
2010	78	1.50	1.49	82.5	27.1	154.0	3.81	2.86	.67	9.5	23.2
2100	80	1.70	1.57	84.4	27.7	160.0	4.10	3.10	.77	8.9	25.0
2320	89	2.25	2.12	98.1	32.2	177.0	5.40	4.28	1.19	7.6	27.7
2636	96	2.60	2.39	104.3	34.2	201.0	6.76	5.56	1.46	6.2	26.3

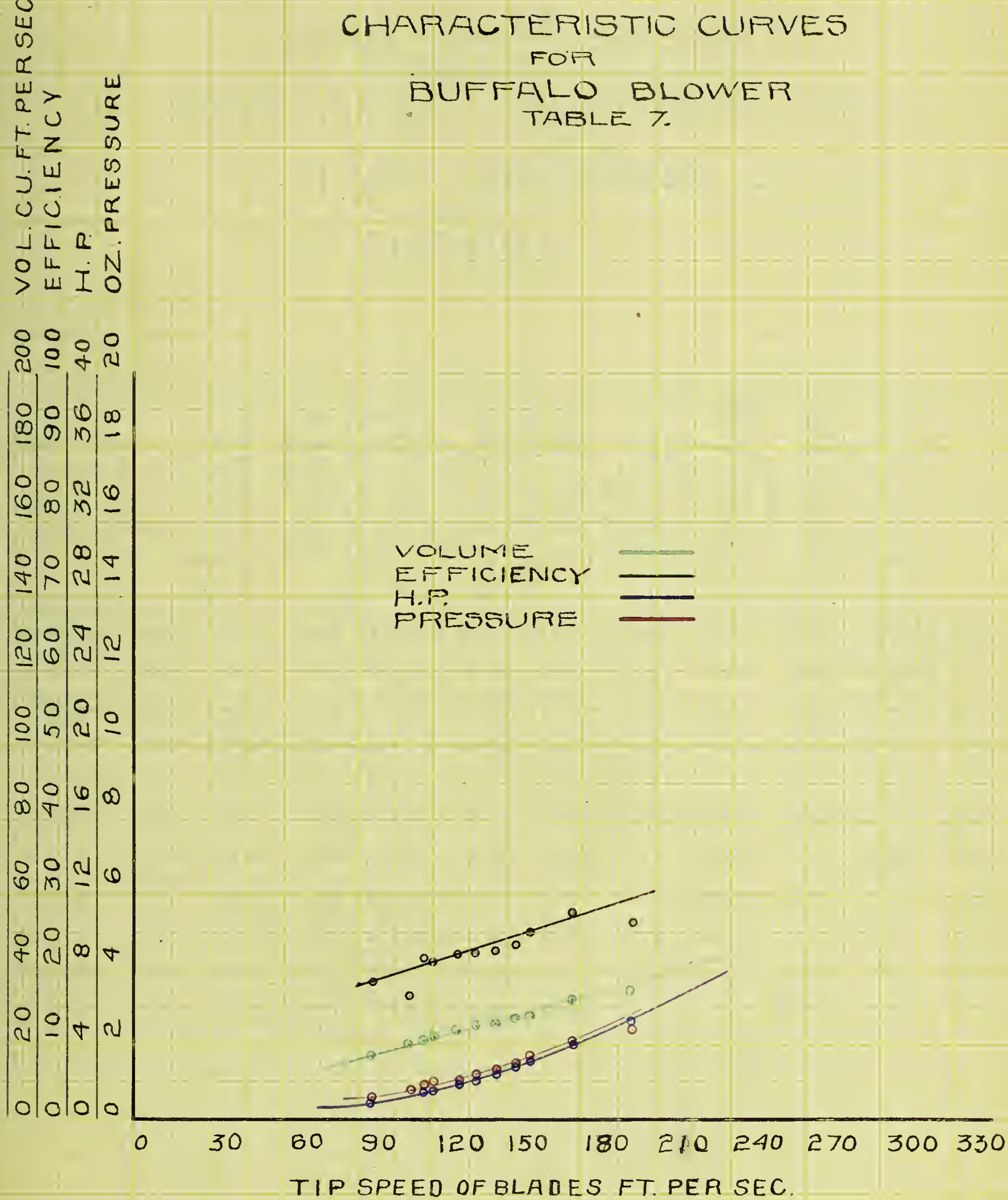

CHARACTERISTIC CURVES
FOR
BUFFALO BLOWER
TABLE 7.
VOL. CU. FT. PER SEC.
EFFICIENCY
H.P.
OZ. PRESSURE
VOLUME
EFFICIENCY
H.P.
PRESSURE
TIP SPEED OF BLADES FT. PER SEC.
0 30 60 90 120 150 180 210 240 270 300 330
0 20 40 60 80 100 120 140 160 180 200
0 10 20 30 40 50 60 70 80 90 100
0 4 8 12 16 20 24 28 32 36 40
0 2 4 6 8 10 12 14 16 18 20

TABLE 8.

DATA AND RESULTS FOR BUFFALO BLOWER NO 7.

1/2 OPENING OF DISCHARGE

R.P.M. FAN	R.P.M. ENG.	PRESSURE OZ. PER SQ. IN.	VEL. HEAD IN. WATER	VEL. OF AIR FT. PER. SEC.	AIR DISCH CU. FT. PER. SEC.	VEL. FAN TIPS FT. PER. SEC.	H.P. TOTAL	H.P. TO DRIVE FAN	H.P. THEORETICAL	CU. FT. AIR DISCH. PER. HP. PER. SEC.	EFFICIENCY 0/0.
1324	48	1.1.0	.32	38.3	12.5	101	1.58	.96	.23	13.0	23.4
1420	52	1.30	.40	42.7	14.0	108	1.73	1.06	.29	13.2	28.1
1506	58	1.45	.45	44.6	14.6	115	1.78	1.04	.32	14.0	33.3
1634	63	1.70	.54	49.7	16.3	124	2.14	1.34	.45	12.2	33.8
1722	66	1.75	.60	52.2	17.1	132	2.53	1.69	.49	10.1	29.0
1824	71	2.10	.67	55.5	18.2	139	2.92	2.02	.63	9.7	30.9
1912	75	2.35	.76	60.9	18.5	146	3.10	2.15	.72	9.2	33.2
2002	75	2.50	.78	62.5	20.1	153	3.47	2.52	8.83	8.0	32.8
2140	82	2.90	.88	64.3	21.2	163	3.64	2.61	1.01	6.3	38.7
2314	87	3.50	1.03	68.4	22.4	177	4.10	3.02	1.28	7.4	42.5
2546	96	4.30	1.25	75.5	24.8	195	5.91	4.71	1.75	5.3	37.1

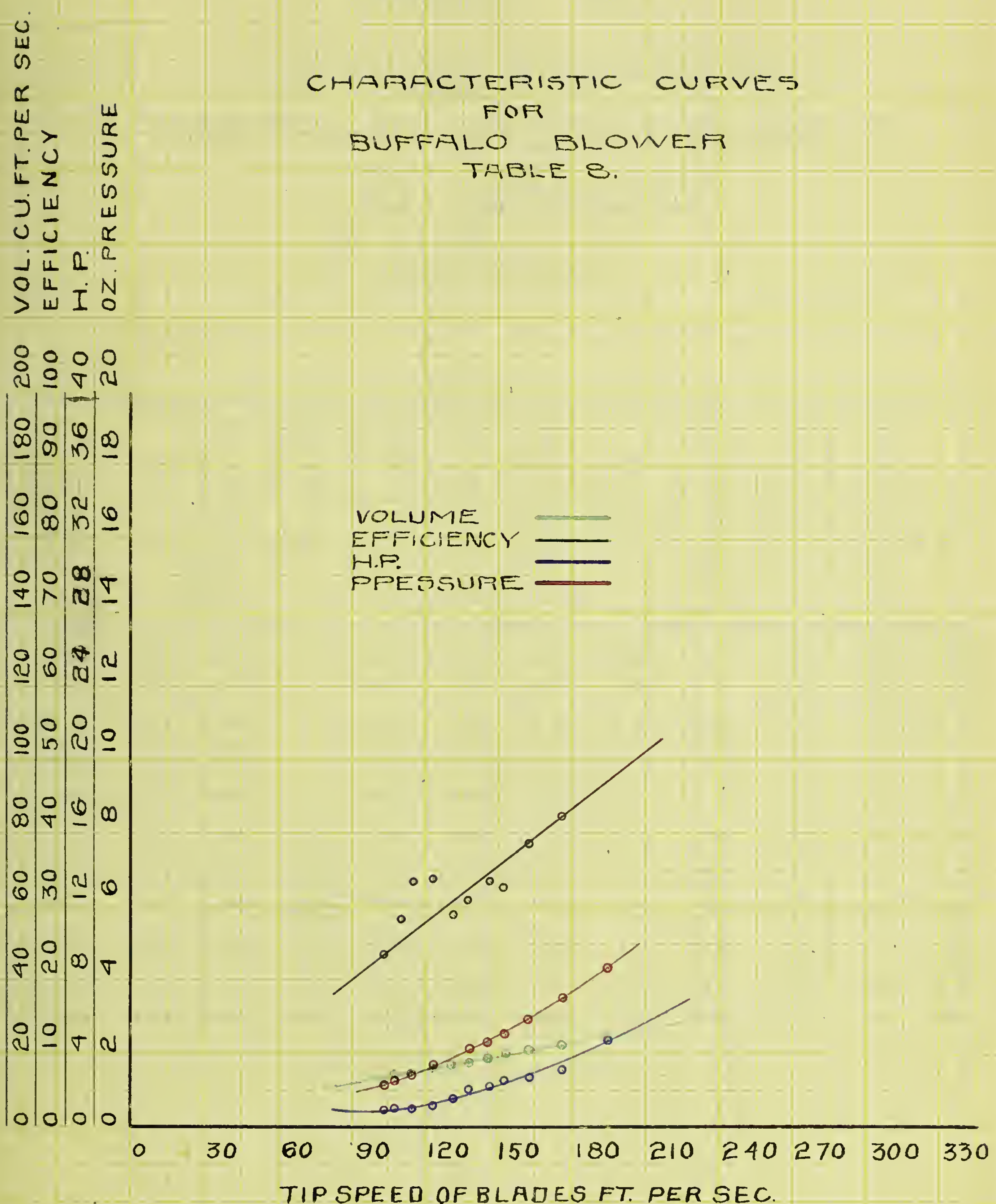

CHARACTERISTIC CURVES
FOR
BUFFALO BLOWER
TABLE 8.
VOL. CU. FT. PER SEC.
EFFICIENCY
H. P.
OZ. PRESSURE
0 20 40 60 80 100 120 140 160 180 200
0 10 20 30 40 50 60 70 80 90 100
0 4 8 12 16 20 24 28 32 36 40
0 2 4 6 8 10 12 14 16 18 20
VOLUME
EFFICIENCY
H.P.
PRESSURE
0 30 60 90 120 150 180 210 240 270 300 330
TIP SPEED OF BLADES FT. PER SEC.

TABLE 9.

DATA AND RESULTS FOR BUFFALO BLOWER NO 7.

1/4 OPENING OF DISCHARGE

R.P.M. FAN	R.P.M. ENG.	PRESSURE OZ. PER. SQ. IN	VEL. HEAD IN WATER	VEL. OF AIR FT. PER SEC.	AIR DISCH. CU. FT. PER. SEC.	VEL. FAN TIPS FT. PER. SEC.	H.P. TOTAL	H.P. TO DRIVE FAN	H.P. THEORETICAL	CU. FT. AIR DISCH. PER. H.P. PER SEC	EFF. 0/0
1344	51	1.35	.1	21.3	7.0	103	2.4	.74	.16	9.5	8.8
1416	54	1.60	.1	21.3	7.0	108	1.6	.93	.18	7.5	19.7
1510	58	1.90	.1	21.3	7.0	115	1.7	.96	.22	7.3	22.7
1666	64	2.20	.1	21.3	7.0	127	1.9	1.09	.25	6.4	23.1
1720	66	2.44	.2	30.2	9.9	132	2.1	1.21	.39	7.7	30.6
1832	70	2.80	.2	30.2	9.9	140	2.3	1.39	.45	7.1	32.6
1920	78	3.20	.23	32.4	10.7	147	2.5	1.50	.56	7.1	37.2
2060	79	3.50	.28	35.4	11.7	157	2.8	1.81	.67	6.4	36.8
2130	82	3.90	.30	37.0	12.2	162	3.0	2.00	.78	6.1	39.0
2300	86	4.40	.33	39.2	12.8	176	3.2	2.12	.93	6.0	43.6
2646	100	5.60	.40	42.7	14.4	202	4.7	3.41	1.32	4.2	38.7

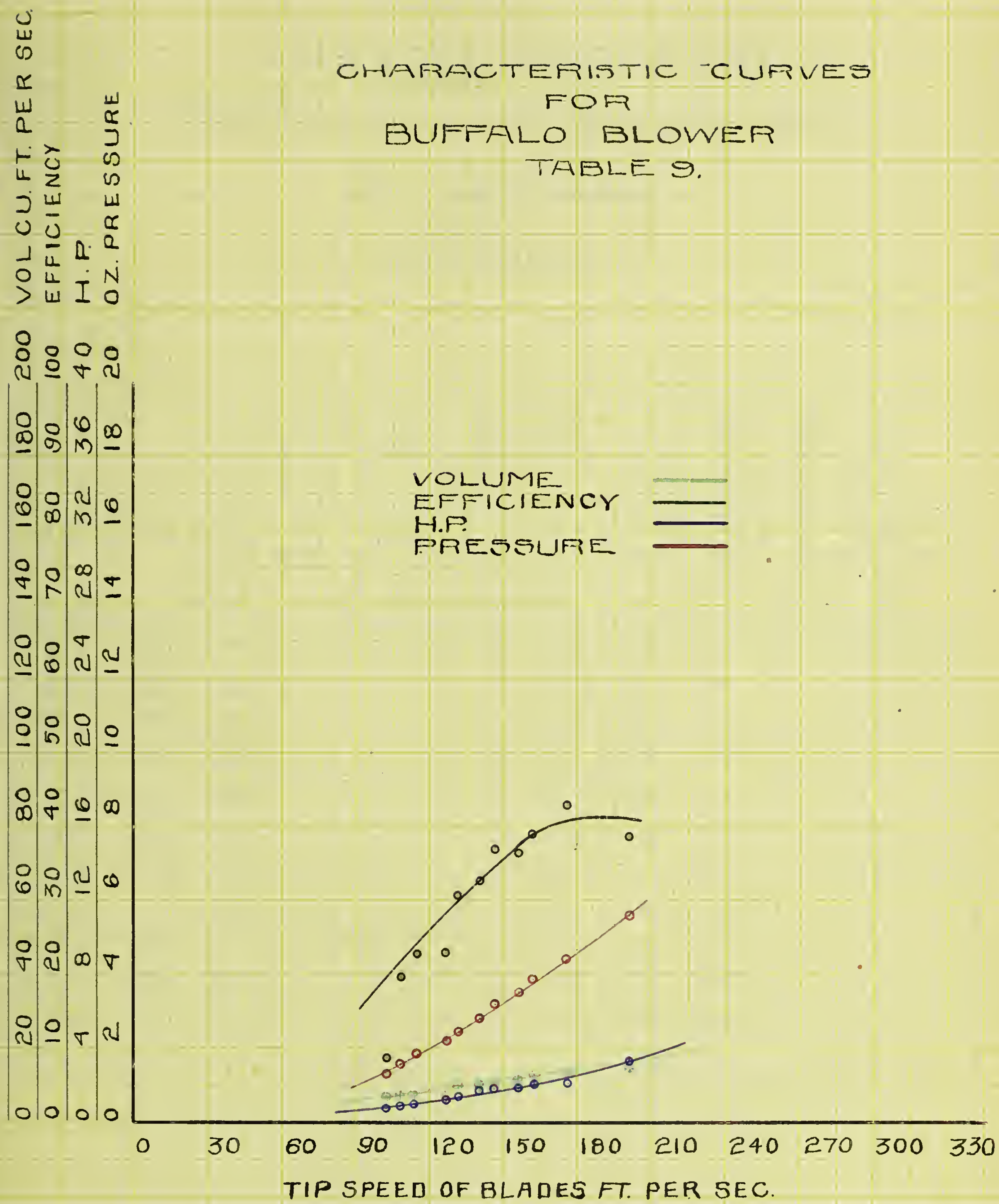
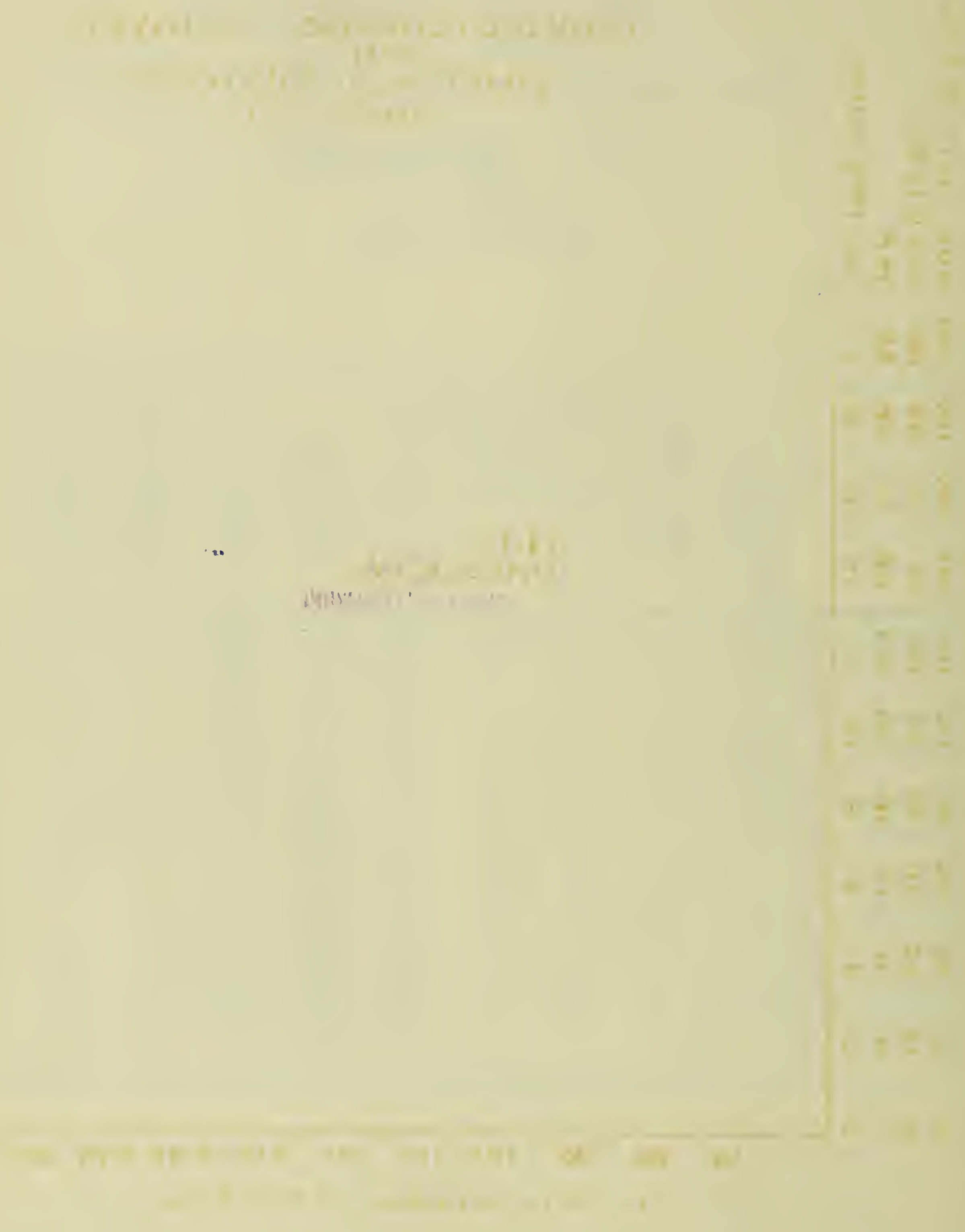

CHARACTERISTIC CURVES
FOR
BUFFALO BLOWER
TABLE 9.
VOL CU. FT. PER SEC.
EFFICIENCY
H.P.
OZ. PRESSURE
0 20 40 60 80 100 120 140 160 180 200
0 10 20 30 40 50 60 70 80 90 100
0 4 8 12 16 20 24 28 32 36 40
0 2 4 6 8 10 12 14 16 18 20
VOLUME
EFFICIENCY
H.P.
PRESSURE
0 30 60 90 120 150 180 210 240 270 300 330
TIP SPEED OF BLADES FT. PER SEC.

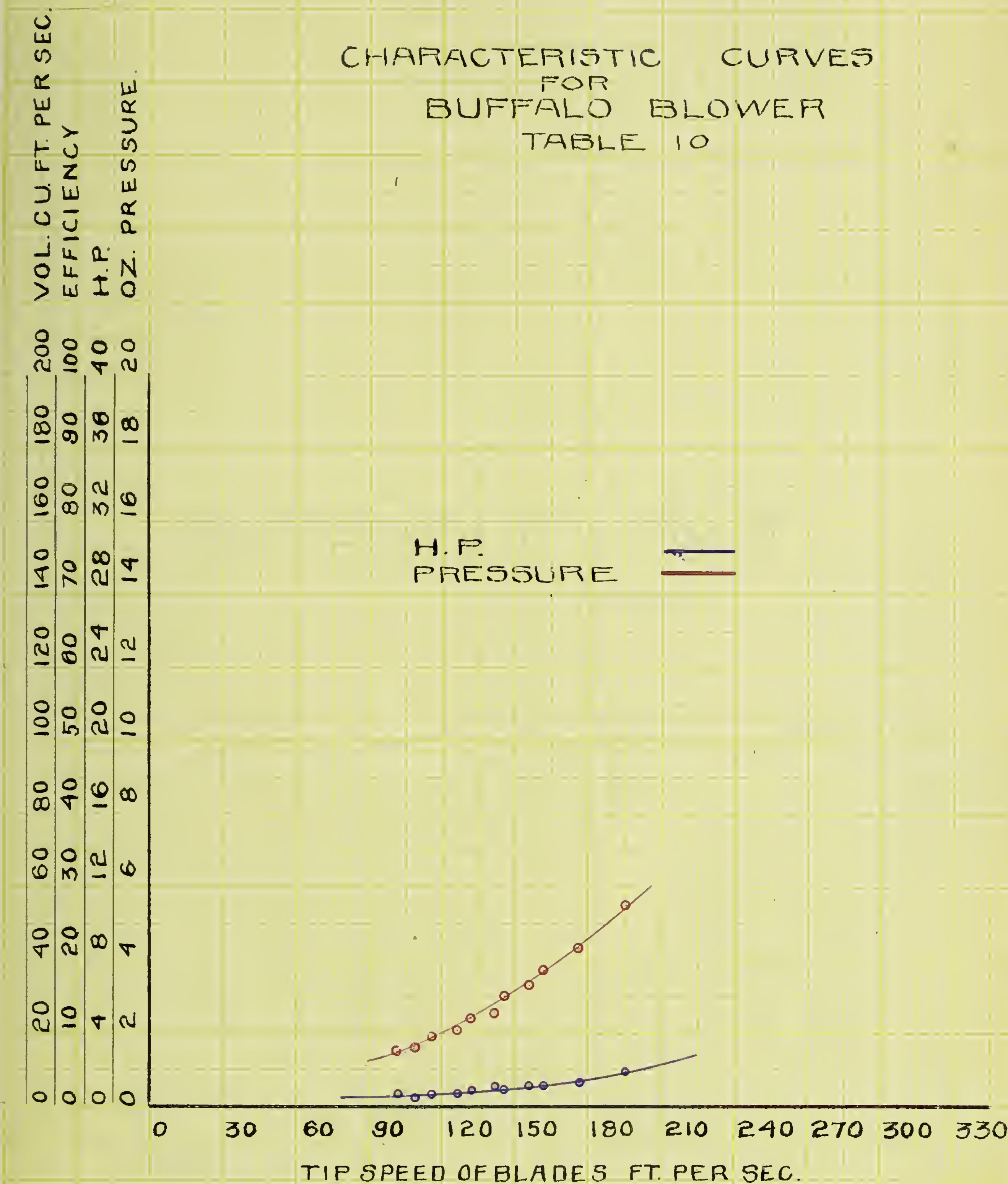
TABLE 10.

DATA AND RESULTS FOR BUFFALO BLOWER NO 7.

O OPENING OF DISCHARGE

R.P.M. FAN	R.P.M. ENG.	PRESSURE OZ.PER.SQ IN	VEL. HEAD IN. WATER	VEL. OF AIR FT. PER. SEC.	AIR DISCH. CU. FT. PER. SEC	VEL. FAN TIPS FT. PER. SEC.	H.P. TOTAL	H.P. TO DRIVE FAN	H.P. THEORETICAL	CU. FT. AIR DISCH PER. H.P. PER SEC.	EFF. o/o.
1340	50	1.50	0	0	0	102	1.38	.73	0	0	0
1430	52	1.60	0	0	0	109	1.21	.54	0	0	0
1520	59	1.90	0	0	0	116	1.38	.66	0	0	0
1666	64	2.20	0	0	0	127	1.46	.69	0	0	0
1732	65	2.40	0	0	0	132	1.66	.83	0	0	0
1856	69	2.70	0	0	0	142	1.80	.93	0	0	0
1924	72	3.00	0	0	0	147	1.73	.81	0	0	0
2018	75	3.25	0	0	0	157	1.95	1.00	0	0	0
2130	82	3.75	0	0	0	163	2.02	.99	0	0	0
2320	84	4.30	0	0	0	177	2.29	1.23	0	0	0
2560	96	5.50	0	0	0	196	3.06	1.86	0	0	0




CHARACTERISTIC CURVES
FOR
BUFFALO BLOWER
TABLE 10
H.P.
PRESSURE
VOL. CU. FT. PER SEC.
EFFICIENCY
H.P.
OZ. PRESSURE
0 20 40 60 80 100 120 140 160 180 200
0 10 20 30 40 50 60 70 80 90 100
0 4 8 12 16 20 24 28 32 36 40
0 2 4 6 8 10 12 14 16 18 20
0 30 60 90 120 150 180 210 240 270 300 330
TIP SPEED OF BLADES FT. PER SEC.

EXPERIMENT NO. 3

Buffalo Volume Blower No 1.

The appearance and details of this blower are identically the same as those of Volume Blower No 8 (See Plate III page 40, and description of No. 8 page 37.) The only difference in the two blowers is that of size.

Table of Dimensions:—

Height Total		28"
Length " "		27½"
Width " "		29⅜"
Diam. of Pulley		5"
Face " " "		4"
Diam. of Shaft		1¼"
Diam. of Blast Wheel		16¼"
Width " " " at	Circ.	4¼"
	Center	6⅛"

No of Blades	5
Size " "	
Area " " "	19.3 sq.in.
Diam. of Discharge Opening	$8\frac{1}{2}$"
Area " " " " "	$56\frac{3}{4}$ sq.in.
Diam " Inlets (two)	8"
Area " " "	100.5 sq.in.
Ratio $\frac{\text{Inlet Area}}{\text{Outlet Area}}$ =	1.2

Temperature and Barometer Readings

Barometer (average)	29.76"
Temperature " "	76.54°F.

TABLE II.

DATA AND RESULTS FOR BUFFALO BLOWER NO 4.

FULL OPENING OF DISCHARGE

R.P.M. FAN	R.P.M. ENG.	PRESSURE OZ. PER. SQ. IN.	VEL HEAD IN. WATER	VEL OF AIR FT. PER. SEC	AIR. DISCH. CU. FT. PER. SEC.	VEL. FAN TIPS FT. PER SEC.	H.P. TOTAL	H.P. TO DRIVE FAN	H.P. THEORETICAL	CU. FT. AIR DISCH PER. H.P. PER. SEC.	EFF. o/o.
822	52	.02	.28	35.7	15.4	58	.55	.39	.004	39.4	1.0
1116	70	.02	.45	45.8	19.7	79	.88	.53	.006	35.4	1.1
1394	87	.02	.75	58.5	25.2	99	1.29	.85	.008	30.0	.9
1718	108	.03	1.07	69.8	29.9	121	2.60	1.96	.015	15.2	.8
1988	125	.04	1.46	81.5	34.8	141	2.90	2.09	.023	16.2	1.1
2320	149	.05	1.97	94.7	40.4	165	4.24	3.23	.034	12.8	1.1
2592	164	.07	2.46	106.0	45.6	184	5.35	4.02	.052	11.3	1.3
2870	187	.10	3.06	118.0	50.7	203	7.67	5.95	.085	8.5	1.4
3234	204	.13	3.94	133.8	57.2	229	10.77	8.69	.122	6.6	1.4
3502	223	.20	4.74	147.0	63.2	248	12.91	10.41	.210	6.0	2.0
3792	242	.21	5.40	1570	67.5	269	16.63	13.68	.233	4.9	1.7

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

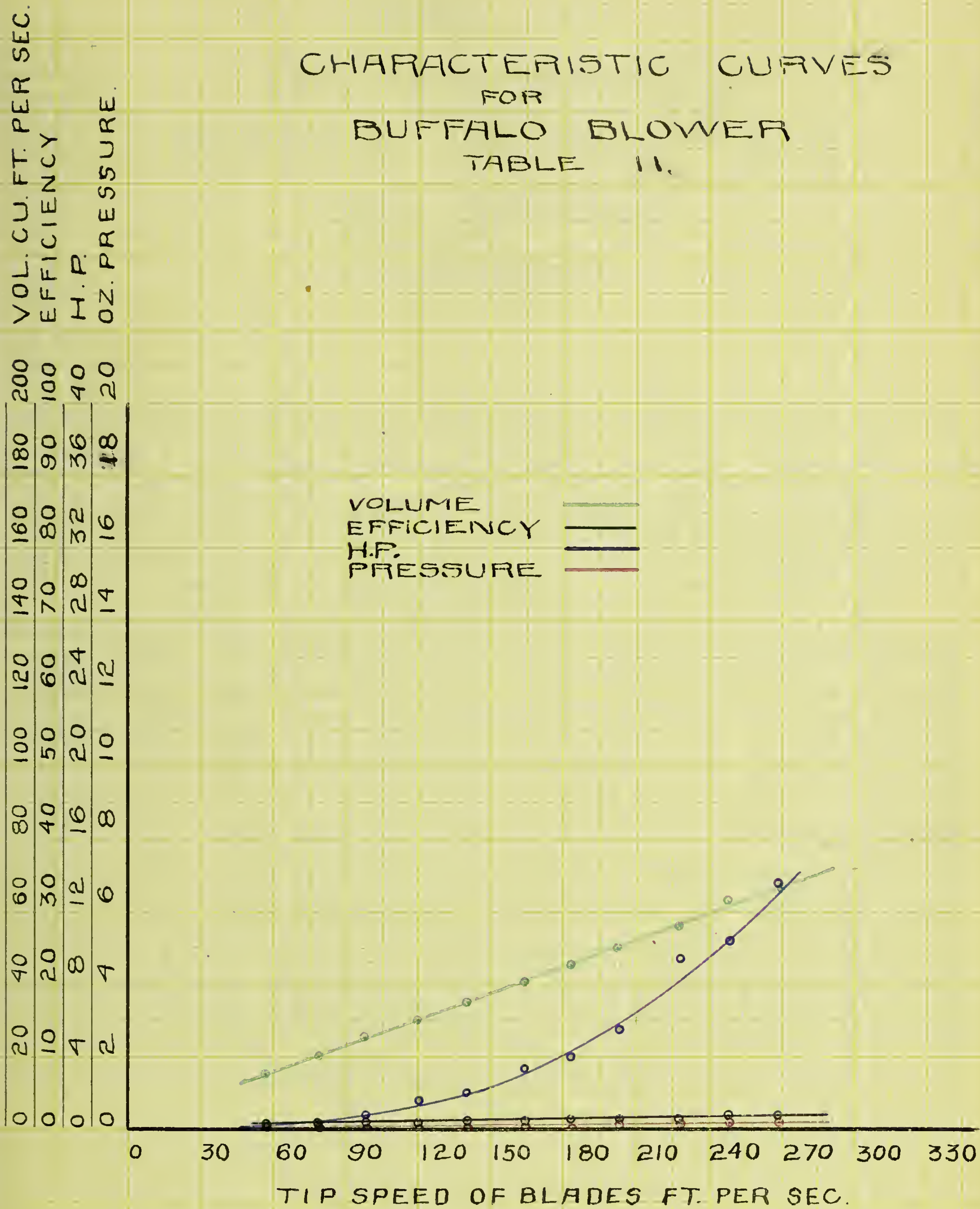

CHARACTERISTIC CURVES
FOR
BUFFALO BLOWER
TABLE 11.
VOL. CU. FT. PER SEC.
EFFICIENCY
H.P.
OZ. PRESSURE
VOLUME
EFFICIENCY
H.P.
PRESSURE
0 30 60 90 120 150 180 210 240 270 300 330
TIP SPEED OF BLADES FT. PER SEC.

TABLE 12.

DATA AND RESULTS FOR BUFFALO BLOWER NO 4.

3/4 OPENING OF DISCHARGE

R.P.M. FAN	R.P.M. ENG.	PRESSURE OZ. PER. SQ. IN.	VEL. HEAD IN WATER	VEL. OF AIR. FT. PER. SEC.	AIR DISCH. CU. FT. PER. SEC.	VEL. FAN TIPS FT. PER SEC.	H.P. TOTAL	H.P. TO DRIVE FAN	H.P. THEORETICAL	CU. FT. AIR DISCH. PER. H.P. PER SEC.	EFF. 0/0.
850	54	.30	.20	30.2	12.9	60	.61	.34	.06	37.9	17.2
1104	70	.33	.35	40.7	17.5	78	.79	.44	.09	40.0	19.5
1410	88	.37	.55	49.8	21.5	100	1.24	.77	.13	28.0	16.9
1708	108	.60	.90	64.0	27.5	121	2.19	1.55	.27	17.7	17.5
1998	126	.75	1.15	72.5	30.8	141	2.82	2.00	.38	15.4	19.0
2292	144	.97	1.49	82.4	35.4	163	3.54	2.50	.56	14.1	22.5
2596	165	1.35	1.86	92.0	39.6	184	4.97	3.62	.88	10.9	24.3
2912	186	1.62	2.33	103.0	44.3	206	6.89	5.19	1.18	8.4	22.8
3205	201	2.12	2.92	115.5	49.7	227	9.08	7.08	1.72	7.0	24.3
3534	226	2.76	3.24	121.5	52.3	250	12.61	10.03	2.36	5.2	22.9
3774	240	3.00	3.75	132.5	56.8	267	14.45	11.53	2.80	5.1	24.2

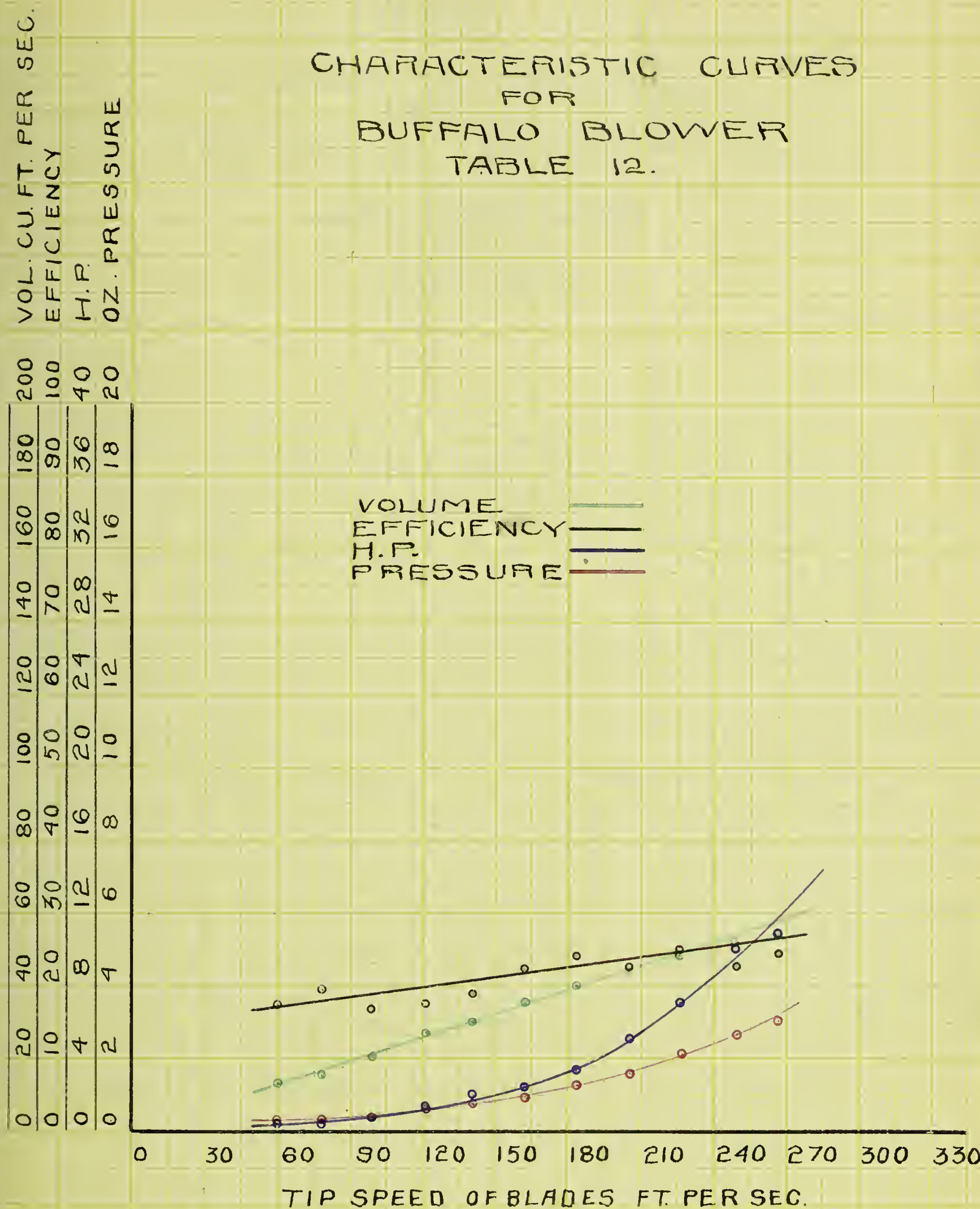

CHARACTERISTIC CURVES
FOR
BUFFALO BLOWER
TABLE 12.
VOLUME
EFFICIENCY
H.P.
PRESSURE
VOL. CU. FT. PER SEC.
EFFICIENCY
H.P.
OZ. PRESSURE
0 20 40 60 80 100 120 140 160 180 200
0 10 20 30 40 50 60 70 80 90 100
0 4 8 12 16 20 24 28 32 36 40
0 2 4 6 8 10 12 14 16 18 20
0 30 60 90 120 150 180 210 240 270 300 330
TIP SPEED OF BLADES FT. PER SEC.

TABLE 13.

DATA AND RESULTS FOR BUFFALO BLOWER NO 4.

1/2 OPENING OF DISCHARGE

R.P.M. FAN	R.P.M. ENG.	PRESSURE OZ. PER. SQ. IN.	VEL. HEAD IN WATER	VEL. OF AIR FT. PER. SEC.	AIR DISCH. CU. FT. PER SEC.	VEL. FAN TIPS FT. PER. SEC.	H.P. TOTAL	H.P. TO DRIVE FAN	H.P. THEORETICAL	CU. FT. AIR DISCH. PER. H.P. PER. SEC.	EFF. %
828	52	.32	.12	23.7	9.9	59	.59	.33	.05	30.0	15.6
1132	71	.64	.22	31.6	13.6	80	.77	.42	.10	32.4	24.7
1428	88	.93	.34	39.5	17.0	101	1.21	.75	.25	22.7	33.4
1698	107	1.20	.43	44.4	19.1	120	1.79	1.16	.38	16.3	33.1
1980	124	1.77	.59	52.1	22.4	140	2.46	1.66	.65	13.5	39.1
2330	147	2.42	.84	61.7	26.5	165	3.20	2.12	1.03	12.5	48.6
2630	166	3.20	1.09	70.5	30.3	186	4.54	3.18	1.58	10.4	49.7
2908	185	4.17	1.31	77.3	33.2	206	5.58	3.93	2.25	8.4	57.4
3205	204	4.90	1.60	85.1	36.6	227	7.91	5.83	2.94	6.3	50.5
3494	222	5.80	1.85	91.8	39.5	247	10.31	7.81	3.76	5.1	48.2
3820	244	7.10	2.32	105.0	45.2	272	12.87	9.87	5.25	4.6	53.2

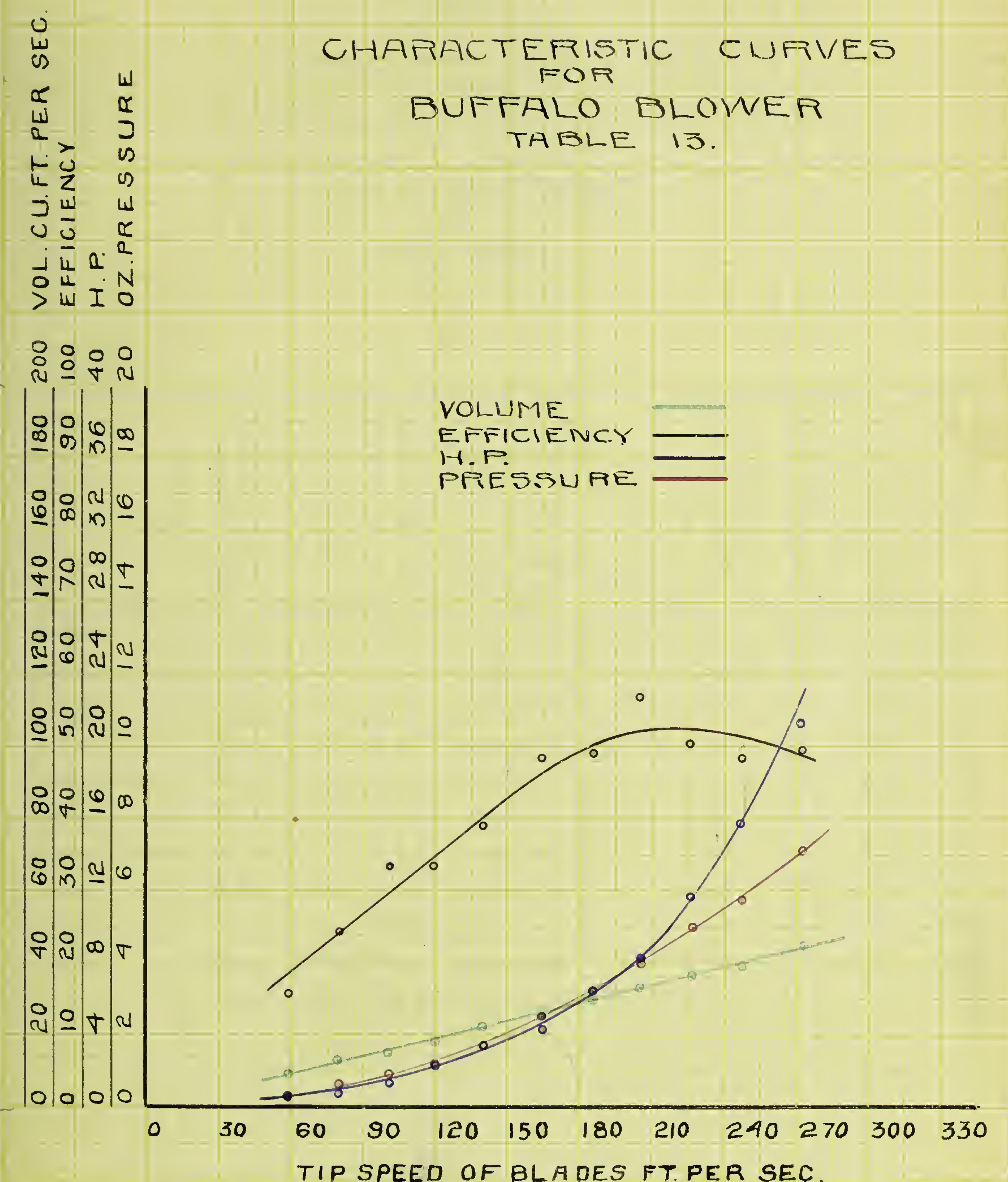

CHARACTERISTIC CURVES
FOR
BUFFALO BLOWER
TABLE 13.
VOL. CU. FT. PER SEC.
EFFICIENCY
H.P.
OZ. PRESSURE
VOLUME
EFFICIENCY
H.P.
PRESSURE
0 20 40 60 80 100 120 140 160 180 200
0 10 20 30 40 50 60 70 80 90 100
0 4 8 12 16 20 24 28 32 36 40
0 2 4 6 8 10 12 14 16 18 20
0 30 60 90 120 150 180 210 240 270 300 330
TIP SPEED OF BLADES FT. PER SEC.

TABLE 14.

DATA AND RESULTS FOR BUFFALO BLOWER NO 4.

1/4 OPENING OF DISCHARGE

R.P.M FAN	R.P.M ENG.	PRESSURE OZ.PER SQ. IN.	VEL. HEAD IN. WATER	VEL OF AIR FT PER SEC	AIR DISCH. CU. FT. PER. SEC.	VEL. FAN TIPS FT. PER. SEC.	H.P. TOTAL	H.P. TO DRIVE FAN	H.P THEORETICAL	CU. FT AIR DISCH. PER H.P. PER. SEC.	EFF. %
744	50	.56	.03	11.7	5.0	53	.47	.22	.05	22.7	20.9
1088	69	.92	.07	17.0	7.3	77	.62	.28	.11	26.0	39.3
1435	90	1.38	.10	21.2	9.0	102	.95	.46	.21	19.6	43.3
1698	107	2.08	.13	24.7	10.6	120	1.61	.98	.36	10.8	36.5
1980	124	2.71	.18	28.2	12.1	140	1.91	1.11	.54	10.8	48.7
2318	146	3.72	.27	34.8	15.0	164	2.48	1.42	.92	10.6	64.7
2622	166	4.76	.34	39.4	16.9	186	3.54	2.18	1.32	8.2	60.5
2902	183	5.90	.41	43.4	18.6	206	4.00	3.36	1.80	5.5	53.6
3196	203	7.50	.51	48.2	20.7	226	5.98	3.93	2.62	5.4	66.6
3540	225	9.50	.58	51.4	22.1	255	7.77	5.22	3.50	4.3	67.0
3778	240	10.50	.67	55.3	23.8	268	8.89	5.97	4.10	4.0	68.0

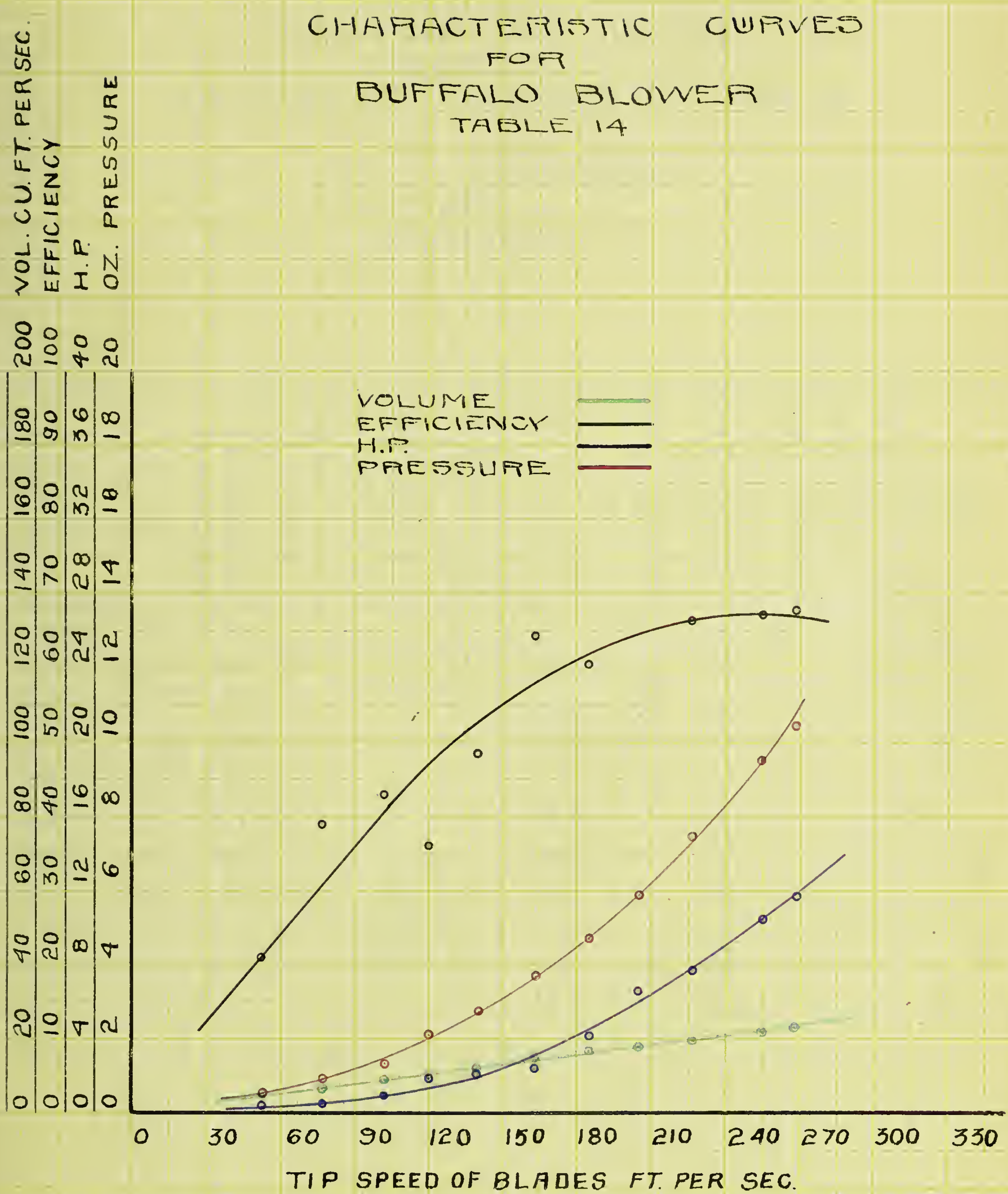
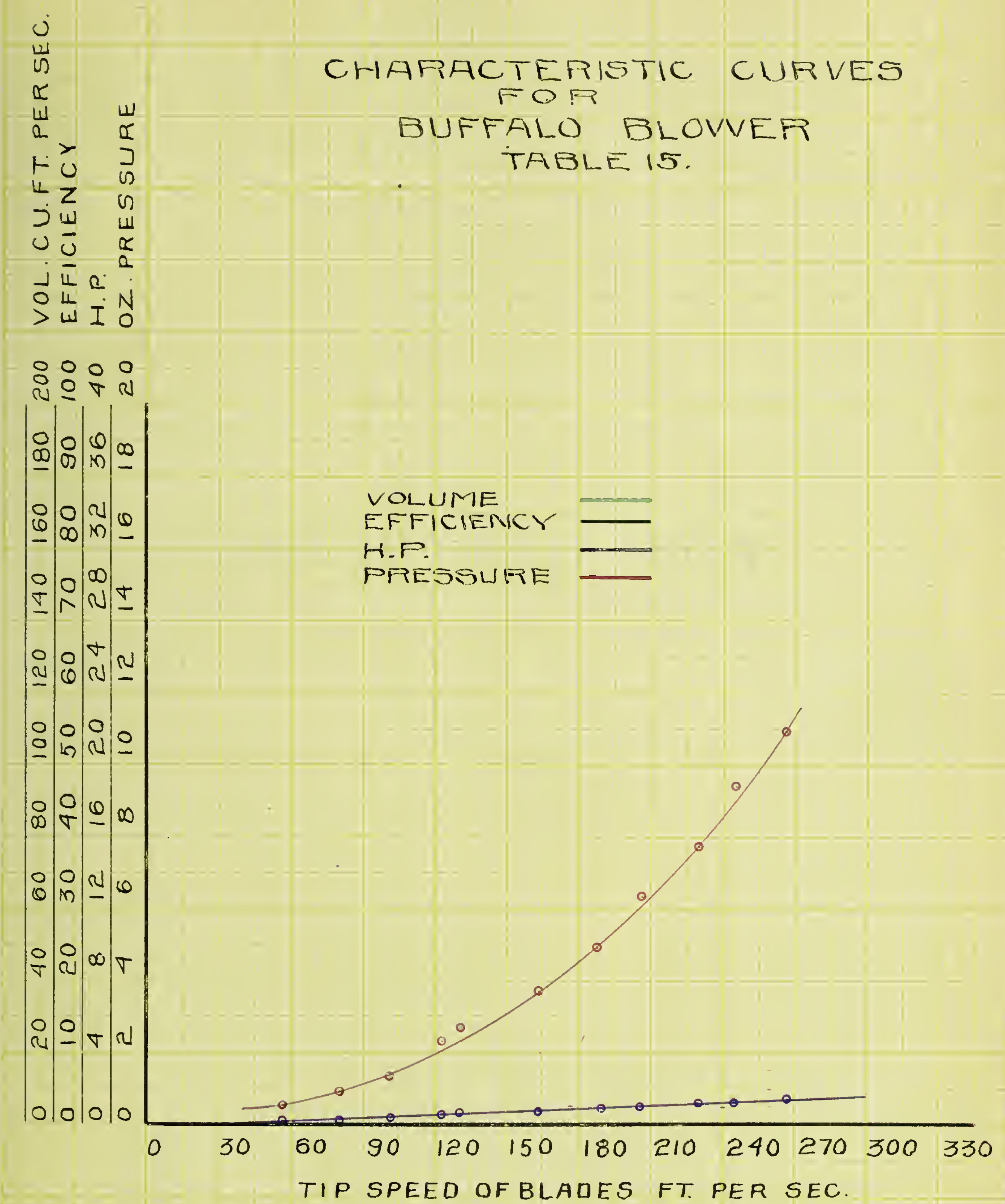

CHARACTERISTIC CURVES
FOR
BUFFALO BLOWER
TABLE 14
VOL. CU. FT. PER SEC.
EFFICIENCY
H.P.
OZ. PRESSURE
VOLUME
EFFICIENCY
H.P.
PRESSURE
0 30 60 90 120 150 180 210 240 270 300 330
TIP SPEED OF BLADES FT. PER SEC.

TABLE 15.

DATA AND RESULTS FOR BUFFALO BLOWER NO 4.

0 OPENING OF DISCHARGE

R.P.M. FAN	R.P.M. ENG	PRESSURE OZ. PER. SQ IN	VEL. HEAD IN WATER	VEL. OF AIR FT. PER. SEC	AIR DISCH. CU. FT. PER. SEC.	VEL. FAN TIPS FT. PER. SEC.	H.P. TOTAL	H.P. TO DRIVE FAN	H.P. THEORETICAL	CU. FT. AIR DISCH. PER. H.P. PER SEC.	EFF. 0/0.
800	50	.53	0	0	0	57	.31	.16	0	0	0
1120	69	.92	0	0	0	80	.57	.23	0	0	0
1418	70	1.37	0	0	0	101	.63	.38	0	0	0
1738	109	2.28	0	0	0	123	1.23	.59	0	0	0
1984	124	2.87	0	0	0	131	1.40	.60	0	0	0
2318	147	3.70	0	0	0	164	1.75	.67	0	0	0
2652	167	4.92	0	0	0	188	2.20	.92	0	0	0
2916	183	6.30	0	0	0	207	2.64	1.00	0	0	0
3244	205	7.70	0	0	0	230	3.19	1.18	0	0	0
3470	220	9.40	0	0	0	246	4.18	1.26	0	0	0
3770	240	10.70	0	0	0	267	4.41	1.34	0	0	0


CHARACTERISTIC CURVES
FOR
BUFFALO BLOWER
TABLE 15.
VOL. CU. FT. PER SEC.
EFFICIENCY
H.P.
OZ. PRESSURE
0 20 40 60 80 100 120 140 160 180 200
0 10 20 30 40 50 60 70 80 90 100
0 4 8 12 16 20 24 28 32 36 40
0 2 4 6 8 10 12 14 16 18 20
VOLUME
EFFICIENCY
H.P.
PRESSURE
0 30 60 90 120 150 180 210 240 270 300 330
TIP SPEED OF BLADES FT. PER SEC.

EXPERIMENT NO. 4

Sturtevant Blower No 1

See Plate 4 page 81:- This is the smallest size of pressure blower built for the general trade and is suitable for all purposes where a small volume of air at a pressure of from five to ten ounces is desired. Its casing, constructed of cast iron has two inlet openings. The blast wheel is constructed almost entirely of steel sheeting, there being twelve blades riveted to conical side plates and the whole carried by and fastened to the hub by means of steel spokes, in the same way that a bicycle rim is fastened to its hub. The blades are curved from the hub

to the rim of the wheel, in the form of a spiral.

Table of Dimensions:—

Height Total		22½"
Length " "		23½"
Width " "		14"
Diam. of Pulleys		3"
Face " " "		2⅜"
Diam. " Shaft		7/16"
Width of Blast Wheel	Outer	1½"
	Circ.	3½"
Diam. " " " " "		12"
No. of Blades		12
Size " " "		4" x 1½" x 2½"
Area " " "		8 sq. in.
Diam. of Discharge Opening		4¼"
Area " " " " "		14.18 sq. in.
Diam. of Inlets		5"

Area of Outlets (two) 37.77 sq. in.

Ratio $\frac{\text{Inlet Area}}{\text{Outlet Area}} =$ 1.7

Temperature and Barometer Readings.

Barometer Height Av. 29.9

Temperature Av. 80°F.

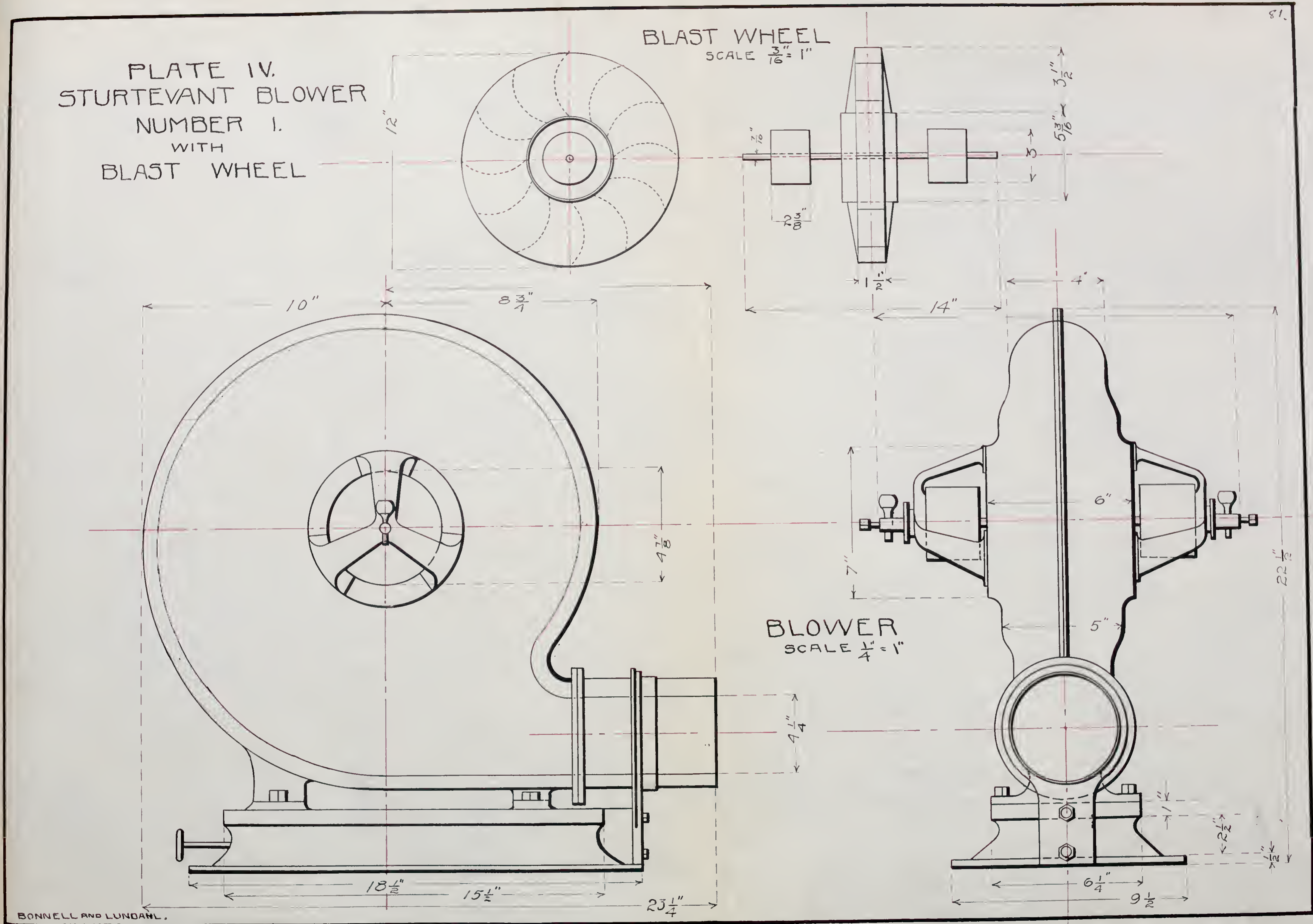


PLATE IV.
STURTEVANT BLOWER
NUMBER 1.
WITH
BLAST WHEEL
BLAST WHEEL
SCALE 3/16" = 1"
BLOWER
SCALE 1/4" = 1"
12"
10"
8 3/4"
4 7/8"
4 1/4"
18 1/2"
15 1/2"
23 1/4"
3 1/2"
5 3/16"
3
7/16"
2 3/8"
1 1/2"
14"
4"
6"
7"
5"
22 1/2"
1"
2 1/2"
1/2"
6 1/4"
9 1/2
BONNELL AND LUNDAHL.

TABLE 16.

DATA AND RESULTS FOR STURTEVANT BLOWER NO 1.

FULL OPENING OF DISCHARGE

R.P.M. FAN	R.P.M. ENG	PRESSURE OZ. PER SQ. IN	VEL. HEAD IN WATER	VEL. OF AIR FT. PER SEC	AIR DISCH CU. FT. PER SEC.	VEL. FAN TIPS FT. PER SEC.	H.P. TOTAL	H.P. TO DRIVE FAN	H.P. THEORETICAL	CU. FT. AIR DISCH. PER H.P. PER SEC.	EFF. o/o
1350	52	.08	.32	38.2	6.7	70.8	.38	.18	.01	32.0	4.5
2048	80	.13	.73	57.7	10.2	102	.82	.48	.02	21.0	4.5
2524	98	.14	1.17	72.7	12.8	132	1.17	.64	.03	20.5	4.6
3060	120	.19	1.54	83.8	14.8	160	1.76	1.01	.05	14.7	4.6
3504	137	.25	2.09	97.7	17.2	184	2.20	1.65	.07	10.4	4.2
3960	150	.32	2.60	109.2	19.2	207	3.25	2.07	.11	9.3	4.8
4508	176	.36	3.41	124.5	21.9	240	4.26	2.76	.13	7.9	4.7
5034	200	.42	3.97	134.5	23.6	263	5.85	3.85	.16	6.1	4.2
5440	214	.44	4.78	148.0	26.1	284	6.99	4.74	.19	5.5	4.0
6080	238	.56	5.61	160.0	28.2	318	8.90	6.11	.26	4.6	4.2
6470	266	.66	6.08	167.0	29.4	388	11.17	7.57	.32	3.8	4.2

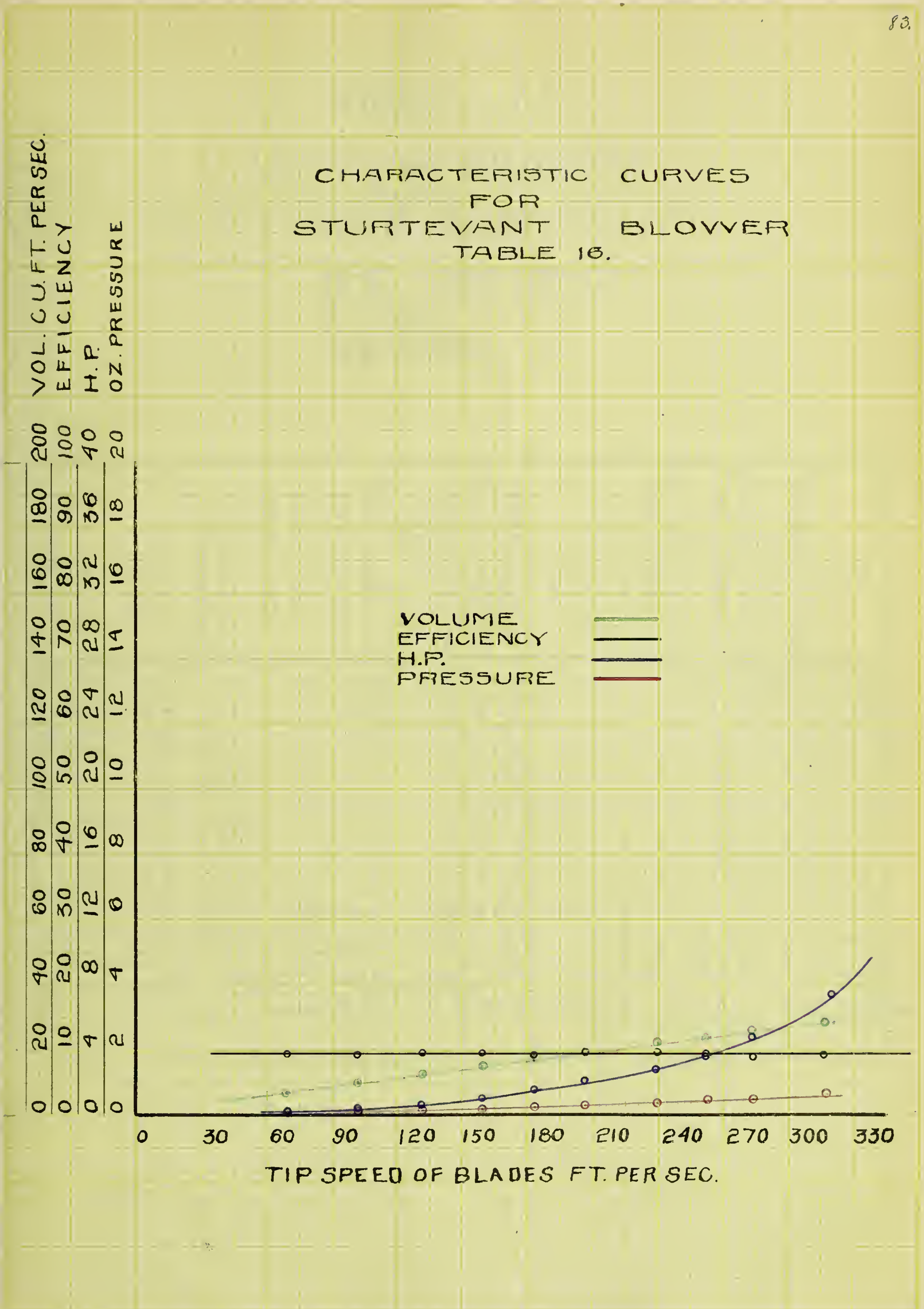

CHARACTERISTIC CURVES
FOR
STURTEVANT BLOWER
TABLE 16.
VOL. CU. FT. PER SEC.
EFFICIENCY
H.P.
OZ. PRESSURE
0 20 40 60 80 100 120 140 160 180 200
0 10 20 30 40 50 60 70 80 90 100
0 4 8 12 16 20 24 28 32 36 40
0 2 4 6 8 10 12 14 16 18 20
VOLUME
EFFICIENCY
H.P.
PRESSURE
0 30 60 90 120 150 180 210 240 270 300 330
TIP SPEED OF BLADES FT. PER SEC.

TABLE 17.

DATA AND RESULTS FOR STURTEVANT BLOWER NO 1.

1/3 OPENING OF DISCHARGE

R.P.M. FAN	R.P.M. ENG.	PRESSURE OZ. PER. SQ. IN	VEL. HEAD IN. WATER	VEL OF AIR FT. PER SEC.	AIR DISCH. CU. FT. PER. SEC.	VEL. FAN TIPS FT. PER. SEC.	H.P. TOTAL	H.P. TO DRIVE FAN	H.P. THEORETICAL	CU. FT. AIR DISCH. PER. H.P. PER SEC.	EFF. %
1310	52	.56	.08	18.5	3.3	69	.36	.18	.03	18.2	57.0
2120	83	1.44	.18	28.6	5.0	111	.71	.29	.19	17.4	65.6
2496	96	2.00	.25	33.8	6.0	131	.93	.32	.20	18.6	60.8
3024	118	2.90	.39	42.1	7.4	158	1.63	.59	.35	12.6	60.0
3478	138	3.90	.53	49.2	8.7	182	1.91	.96	.56	9.1	57.8
4028	156	5.25	.71	56.9	10.0	210	2.44	1.24	.88	8.2	70.6
4480	174	6.44	.85	62.2	11.0	235	3.49	1.89	1.16	5.8	61.2
4990	196	8.07	1.25	75.4	13.3	261	4.62	2.72	1.76	4.9	64.6
5510	217	9.70	1.29	76.6	13.5	288	5.44	3.32	2.14	4.1	64.5
6074	236	11.90	1.55	84.0	14.8	318	7.29	4.49	2.89	3.3	64.4
6580	260	13.10	1.68	87.5	15.4	345	10.12	6.78	3.31	2.3	49.8

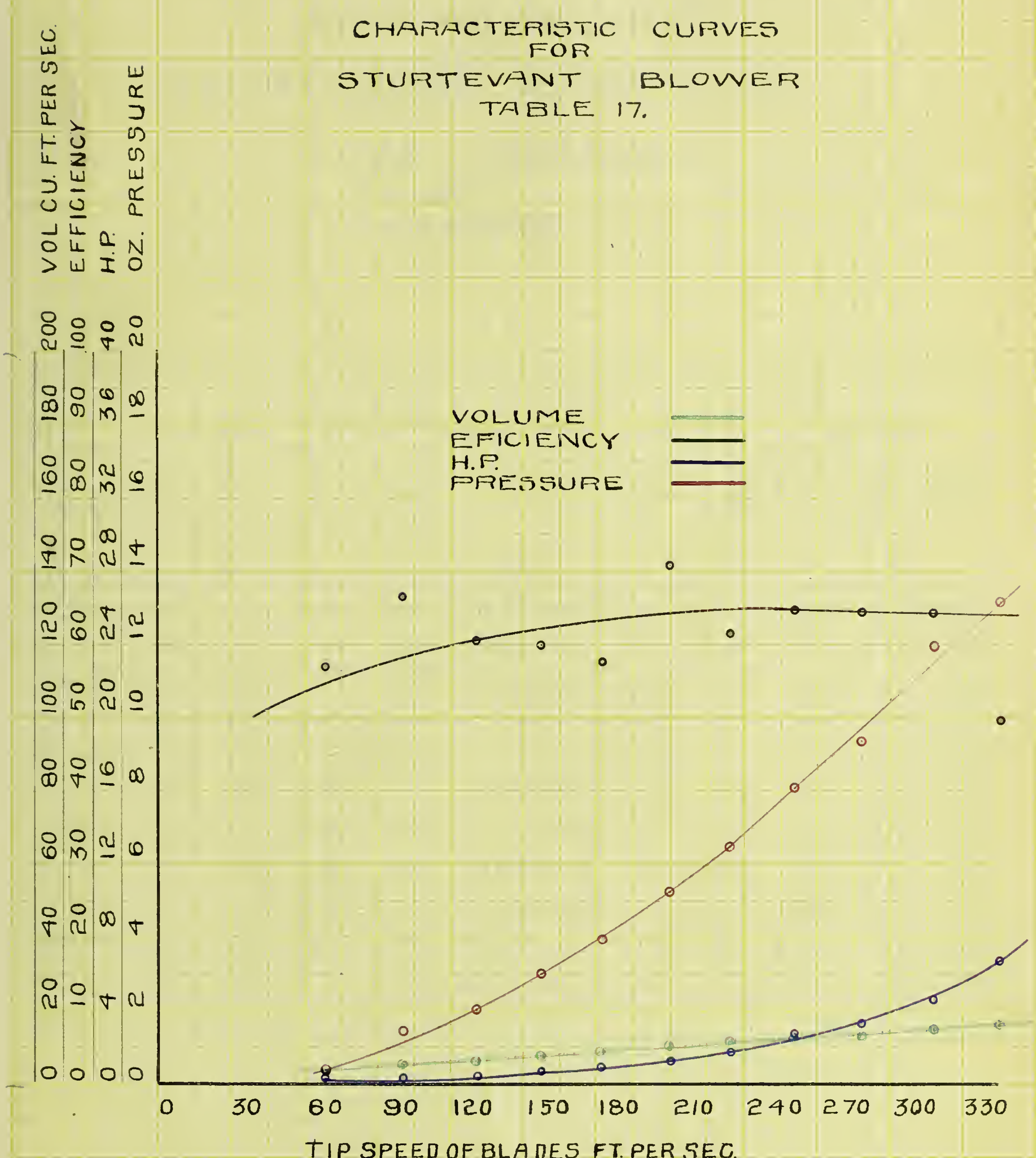

CHARACTERISTIC CURVES
FOR
STURTEVANT BLOWER
TABLE 17.
VOL CU. FT. PER SEC.
EFFICIENCY
H.P.
OZ. PRESSURE
VOLUME
EFICIENCY
H.P.
PRESSURE
0 20 40 60 80 100 120 140 160 180 200
0 10 20 30 40 50 60 70 80 90 100
0 4 8 12 16 20 24 28 32 36 40
0 2 4 6 8 10 12 14 16 18 20
0 30 60 90 120 150 180 210 240 270 300 330
TIP SPEED OF BLADES FT. PER SEC.

TABLE 18.

DATA AND RESULTS FOR STURTEVANT BLOWER NO 1.

2/3 OF OPENING DISCHARGE

R.P.M. FAN	R.P.M. ENG.	PRESSURE OZ. PER SQ. IN	VEL. HEAD IN. WATER	VEL. OF AIR FT. PER SEC.	AIR DISCH CU. FT. PER. SEC.	VEL. FAN TIPS FT. PER SEC.	H.P. TOTAL	H.P. TO DRIVE FAN	H.P. THEORETICAL	CU. FT. AIR DISCH. PER H.P. PER SEC.	EFF. o/o
1350	52	.29	.24	33	5.8	70.8	.37	.12	.03	44.3	22.3
2114	82	.70	.51	48	8.5	110.5	.77	.36	.09	23.4	24.8
2478	97	.97	.71	57	10.0	129.8	1.09	.57	.15	17.7	27.2
3070	120	1.53	1.03	69	12.0	161.0	1.62	.87	.30	14.7	34.7
3440	135	1.90	1.00	68	11.9	180.0	1.94	1.02	.38	11.7	37.4
3940	154	2.25	1.70	88	15.5	206.5	2.70	1.53	.57	10.2	33.8
4520	175	3.10	2.22	100	17.7	236.0	3.88	2.38	.90	7.4	37.8
5030	200	3.70	2.63	109	19.2	263.0	5.40	3.40	1.15	5.7	34.0
5470	214	4.30	3.20	120	21.2	286.0	6.12	4.06	1.49	5.2	36.7
6060	237	5.40	3.85	132	23.2	317.0	9.02	6.22	2.06	3.7	33.1
6520	260	6.40	4.70	146	25.7	341.0	10.55	7.15	2.69	3.8	37.4

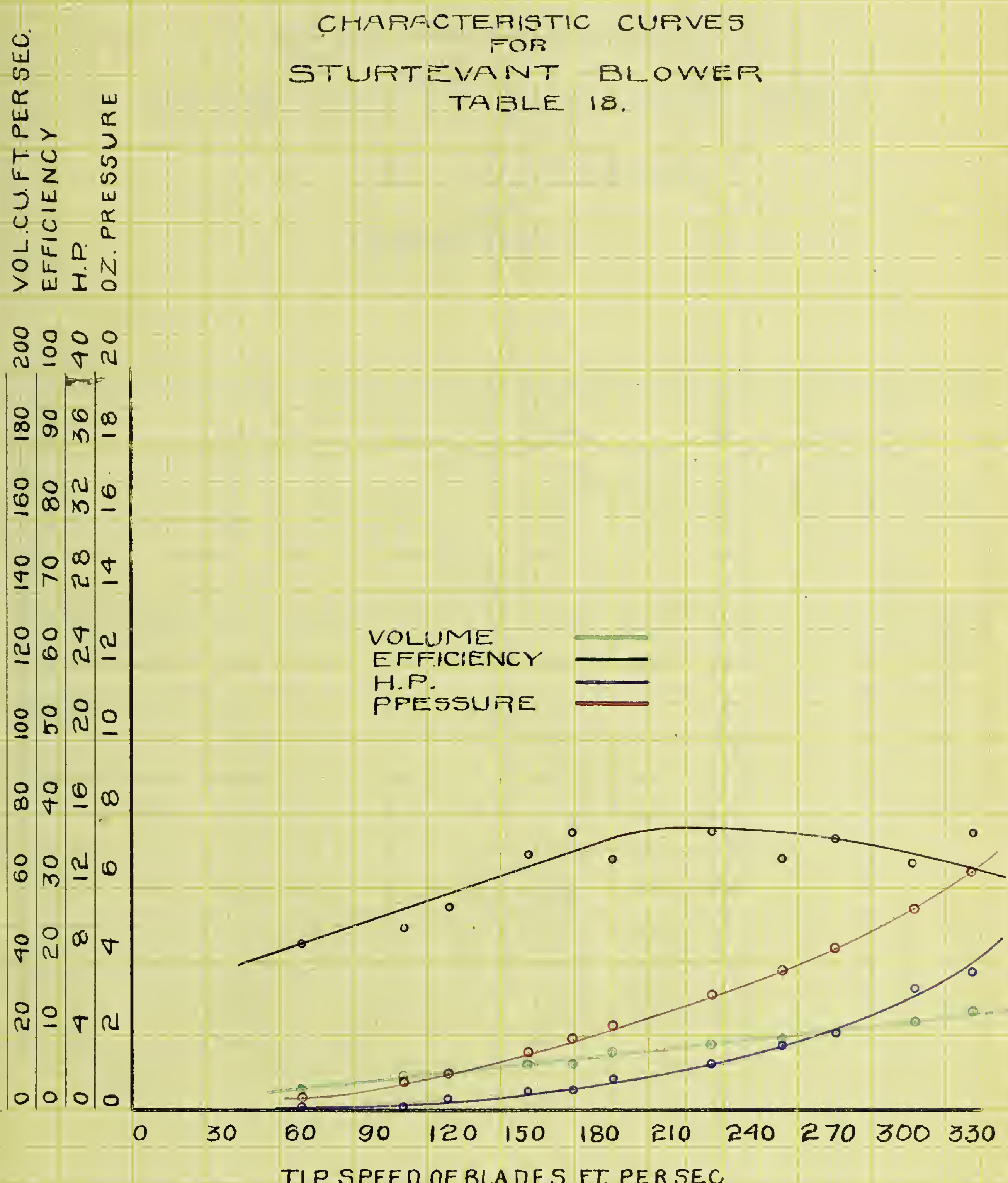
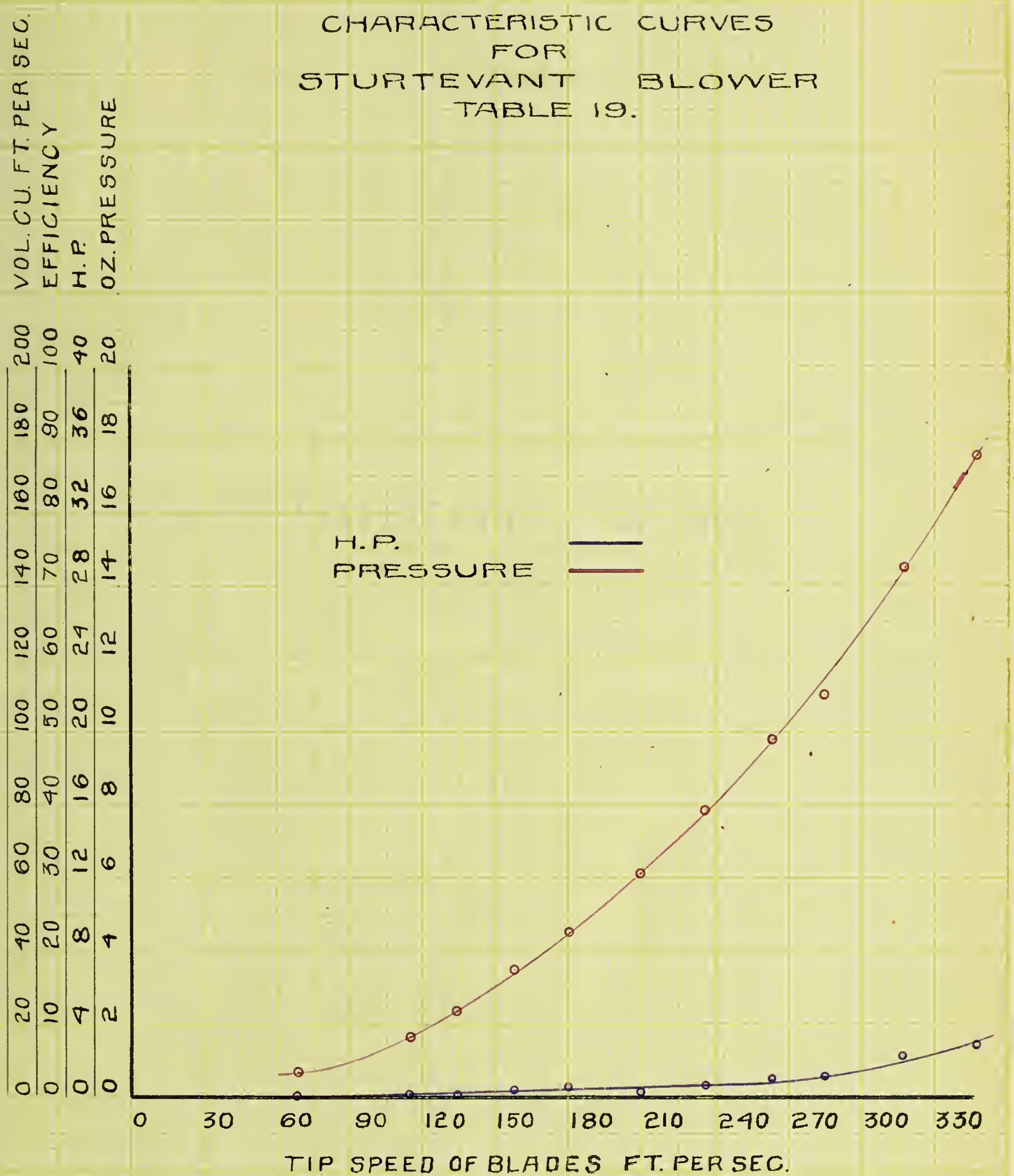

CHARACTERISTIC CURVES FOR STURTEVANT BLOWER TABLE 18.
VOL. CU. FT. PER SEC.
EFFICIENCY
H.P.
OZ. PRESSURE
0 20 40 60 80 100 120 140 160 180 200
0 10 20 30 40 50 60 70 80 90 100
0 4 8 12 16 20 24 28 32 36 40
0 2 4 6 8 10 12 14 16 18 20
VOLUME
EFFICIENCY
H.P.
PRESSURE
0 30 60 90 120 150 180 210 240 270 300 330
TIP SPEED OF BLADES FT. PER SEC.

TABLE 19.

DATA AND RESULTS
STURTEVANT BLOWER NO 1.
0 OPENING
OF
DISCHARGE

R.P.M. FAN	R.P.M ENG	PRESSURE OZ. PER.SQ.IN.	VEL HEAD IN. WATER	VEL OF AIR FT. PER. SEC.	AIR DISCH. CU.FT. PER. SEC.	VEL. FAN TIPS FT. PER SEC.	H.P. TOTAL	H P TO DRIVE FAN	H.P. THEORETICAL	CU.FT. AIR DISCH. PER. H.P. PER. SEC.	EFF. 0/0
1290	50	.74	0	0	0	68	.28	.03	0	0	0
2162	84	1.69	0	0	0	116	.58	.15	0	0	0
2580	100	2.37	0	0	0	134	.73	.18	0	0	0
3020	118	3.50	0	0	0	158	1.11	.39	0	0	0
3440	134	4.56	0	0	0	181	1.43	.53	0	0	0
4010	156	6.18	0	0	0	210	1.56	.36	0	0	0
4502	175	7.90	0	0	0	236	2.20	.69	0	0	0
5030	196	9.80	0	0	0	263	2.88	.98	0	0	0
5450	212	11.00	0	0	0	285	3.38	1.13	0	0	0
6120	238	14.50	0	0	0	320	5.07	2.22	0	0	0
6650	260	17.50	0	0	0	348	6.20	2.80	0	0	0
7050		19.20				369					


CHARACTERISTIC CURVES
FOR
STURTEVANT BLOWER
TABLE 19.
VOL. CU. FT. PER SEC.
EFFICIENCY
H.P.
OZ. PRESSURE
0 20 40 60 80 100 120 140 160 180 200
0 10 20 30 40 50 60 70 80 90 100
0 4 8 12 16 20 24 28 32 36 40
0 2 4 6 8 10 12 14 16 18 20
H. P.
PRESSURE
0 30 60 90 120 150 180 210 240 270 300 330
TIP SPEED OF BLADES FT. PER SEC.

EXPERIMENT NO. 5

35" Buffalo Exhauster.

See Plate I, p.94. This Buffalo Steel Plate Planing Mill Exhauster was constructed of heavy steel plate firmly braced and stiffened with angle irons. A heavy cast iron pedestal, entirely independent of the fan shell, carried the pulley wheel and ring oiling bearings. The exhauster (like all exhausters) had a single inlet orifice and and over hung blast wheel. The latter consisted essentially of a cast iron hub with wrought iron spider arms, conical side plates and steel blades, the tips of which were slightly curved backward.

Table of Dimensions.

Height Total		$39\frac{3}{4}''$
Length " "		$36\frac{1}{4}''$
Width " "		$11\frac{3}{8}''$
Diam. of Pulley		$8''$
Face " " "		$7''$
Diam. of Shaft		$1\frac{3}{4}''$
Length of Bearings		$6\frac{3}{8}$ and $7\frac{5}{8}''$
Diam. of Blast Wheel at	Center	$17\frac{3}{4}''$
	Circ.	$9\frac{1}{2}''$
No. of Blades.		5
Area " " "		86.6 sq.in.
Size of Discharge Opening	Outside of Flange	$13\frac{3}{8}'' \times 13\frac{1}{2}''$
	Inside " " "	$12'' \times 13''$
Area " " " "	Outside of Flange	180 sq.in.
	Inside of Flange	169 sq.in.
Diam. of Inlet	Outside of Flange	$14\frac{5}{8}''$
	Inside " " "	$14\frac{1}{4}''$

Area of Inlet { Outside of Flange 167.9 sq. in.
Inside " " " 159.5 sq. in. }

Ratio $\frac{\text{Inlet Area}}{\text{Outlet Area}} =$ .94

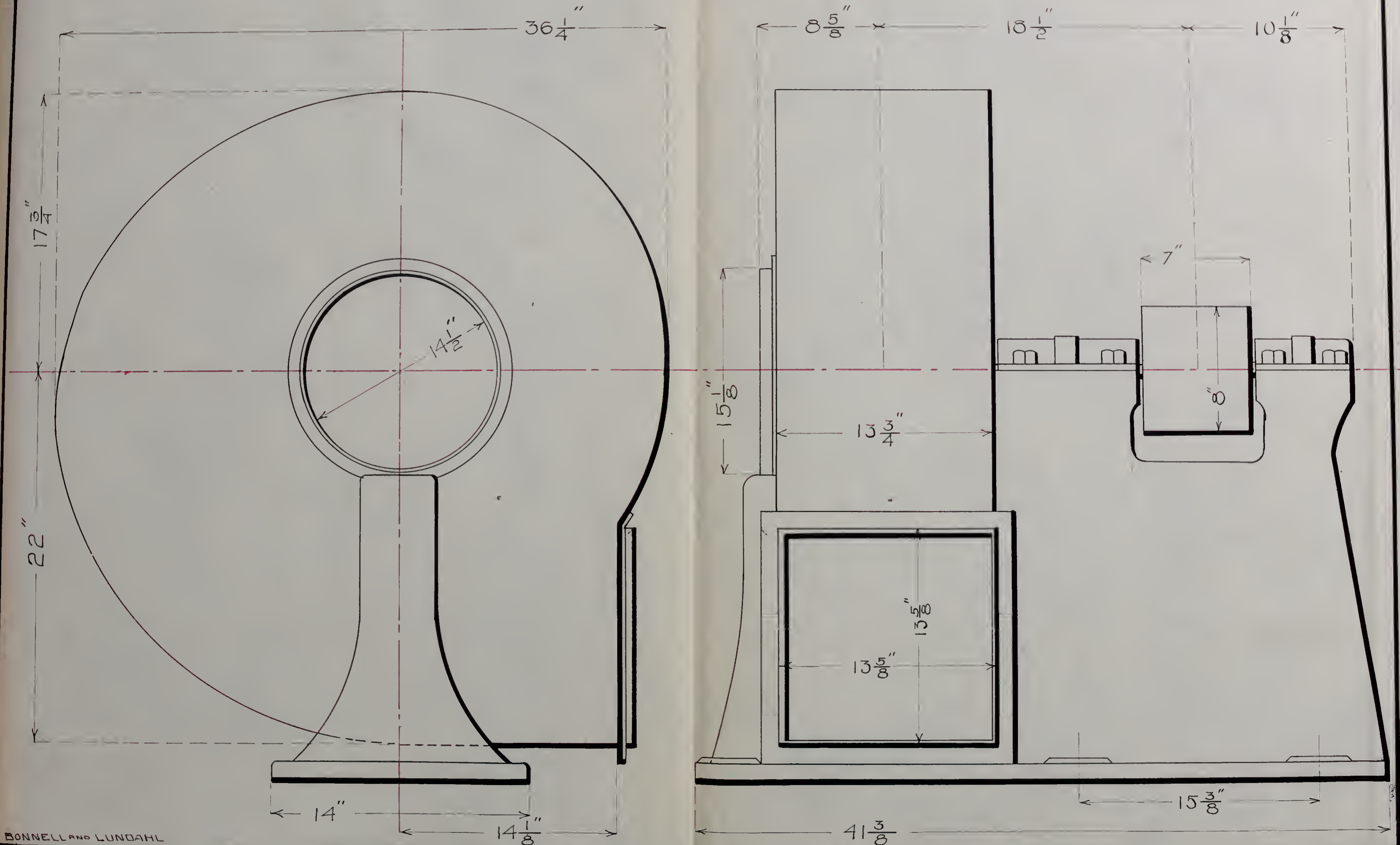
Temperature and Barometer Readings.

Barometer Height Av. 29.99"

Temperature Av. 92⅝° F.

PLATE V.

40" BUFFALO EXHAUSTER

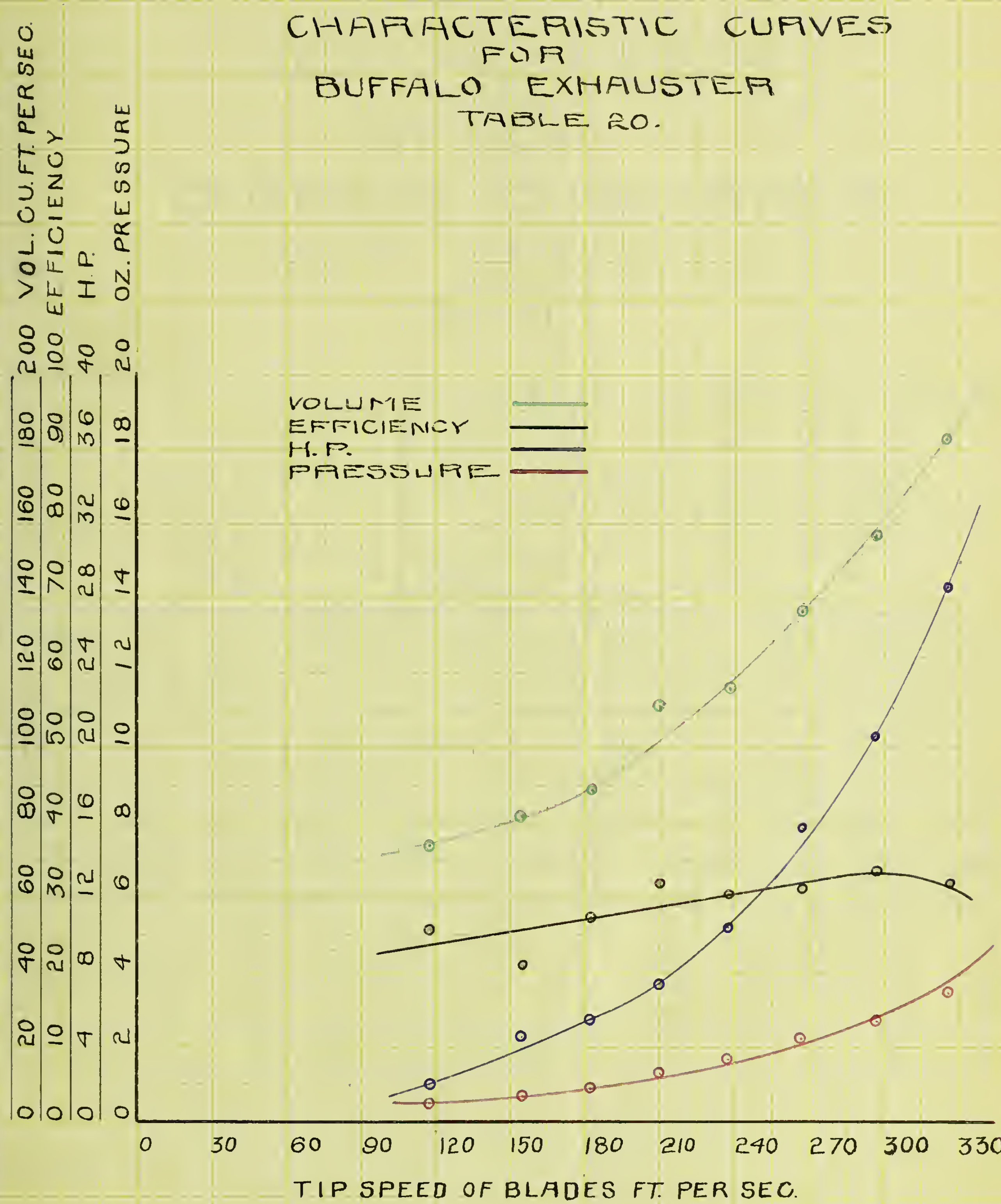


BONNELL AND LUNDAHL

TABLE 20.

DATA AND RESULTS FOR 40″ INCH BUFFALO EXHAUSTER FULL OPENING OF INTAKE

R.P.M. EXH.	R.P.M. ENG.	SUCTION OZ. PER.SQ.IN.	VEL. HEAD IN WATER	VEL OF AIR FT. PER SEC	AIR DISCH. CU.FT. PER.SEC.	VEL EXH.TIPS FT. PER. SEC.	H.P. TOTAL	H.P. TO DRIVE EXH.	H.P. THEORETICAL	CU.FT. AIR DISCH. PER. H.P. PER. SEC.	EFF. o/o
793	77	.45	.58	51.0	74.0	118	2.51	2.11	.55	36.2	25.9
1030	102	.70	.73	57.0	82.4	155	5.07	4.53	.95	18.2	20.9
1203	116	.90	.85	61.5	89.5	182	6.13	5.53	1.51	16.2	27.3
1390	137	1.30	1.32	77.0	111.8	210	8.43	7.48	2.38	115.0	31.9
1572	156	1.70	1.59	84.6	116.0	238	11.75	10.55	3.22	11.0	30.5
1771	182	2.20	2.00	94.7	137.5	267	17.35	15.74	4.95	8.7	31.4
1975	208	2.70	2.56	107.2	157.5	298	22.74	20.59	6.95	7.7	33.6
2160	224	3.45	2.78	112.0	162.6	326	31.20	28.68	9.20	5.7	31.4



CHARACTERISTIC CURVES
FOR
BUFFALO EXHAUSTER
TABLE 20.
VOLUME
EFFICIENCY
H.P.
PRESSURE
VOL. CU. FT. PER SEC.
EFFICIENCY
H.P.
OZ. PRESSURE
0 20 40 60 80 100 120 140 160 180 200
0 10 20 30 40 50 60 70 80 90 100
0 4 8 12 16 20 24 28 32 36 40
0 2 4 6 8 10 12 14 16 18 20
0 30 60 90 120 150 180 210 240 270 300 330
TIP SPEED OF BLADES FT. PER SEC.

TABLE 21.

DATA AND RESULTS FOR 40" INCH BUFFALO EXHAUSTER 3/4 OPENING OF INTAKE

R.P.M. EXH.	R.P.M. ENG.	SUCTION OZ. PER SQ IN	VEL. HEAD IN. WATER	VEL. OF AIR FT. PER. SEC.	AIR DISCH CU. FT. PER SEC.	VEL. EXH. TIPS FT. PER. SEC.	H.P. TOTAL	H.P. TO DRIVE EXH	H.P. THEORETICAL	CU. FT. AIR DISCH. PER H.P. PER. SEC.	EFF. o/o.
807	79	.54	.38	4.1.5	65.0	121.7	2.57	2.17	.53	30.0	24.6
1015	100	.80	.54	49.0	71.2	153.0	4.78	4.23	.93	16.7	21.9
1220	119	1.10	.66	54.2	78.7	184.0	5.97	5.22	1.42	15.3	27.1
1390	137	1.50	1.10	70.0	101.5	210.0	8.07	7.12	2.49	14.2	35.0
1582	161	2.00	1.22	73.0	106.0	239.0	11.74	10.46	3.49	10.1	33.0
1787	182	2.70	1.80	91.2	125.5	270.0	15.65	14.04	5.54	8.9	39.0
1955	202	3.20	2.35	102.5	147.2	295.0	20.57	18.55	7.70	7.9	41.4
2160	229	4.00	2.58	1075	156.2	326.0	28.32	25.67	10.25	6.1	39.9

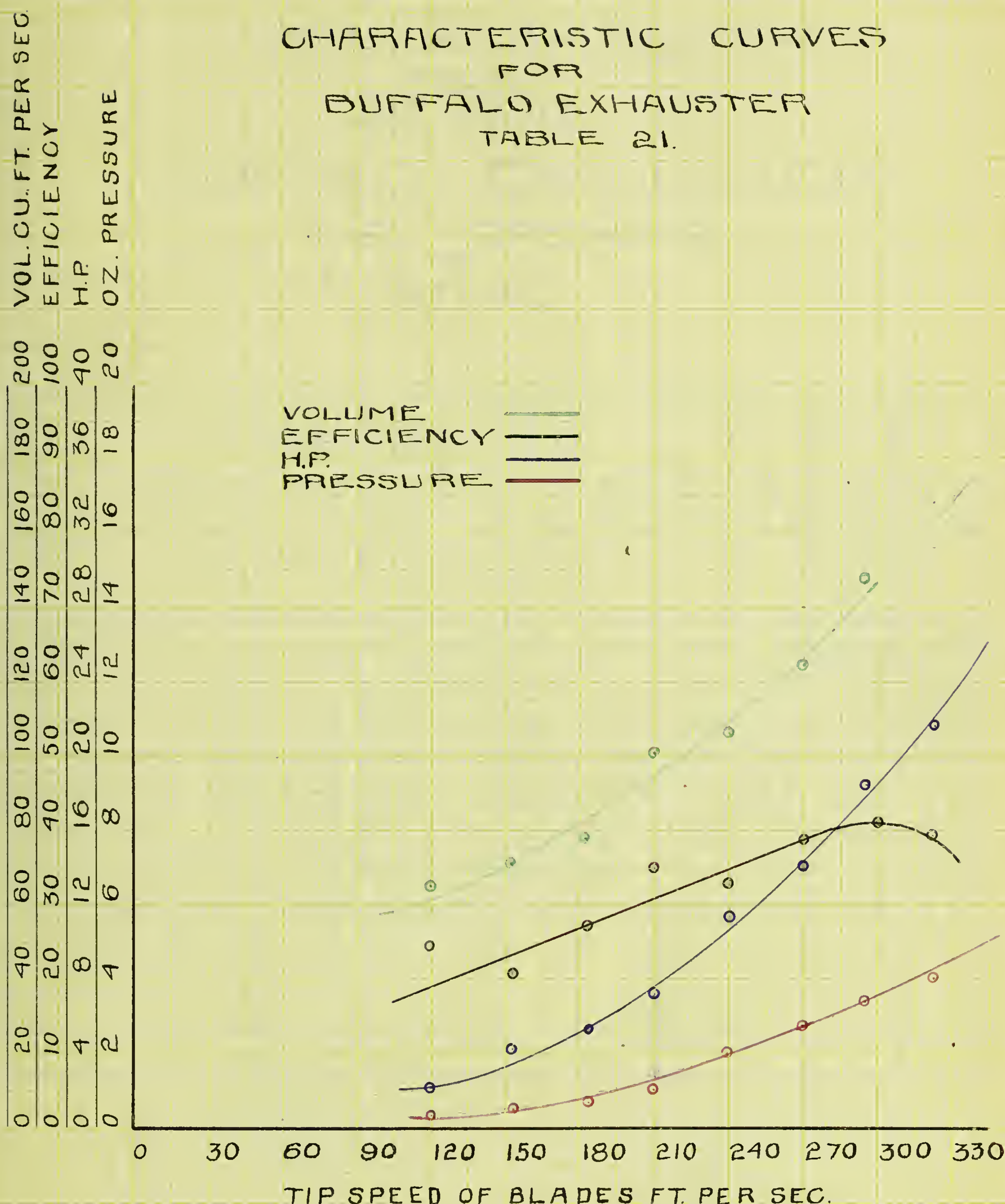

CHARACTERISTIC CURVES
FOR
BUFFALO EXHAUSTER
TABLE 21.
VOL. CU. FT. PER SEC.
EFFICIENCY
H.P.
OZ. PRESSURE
VOLUME
EFFICIENCY
H.P.
PRESSURE
0 20 40 60 80 100 120 140 160 180 200
0 10 20 30 40 50 60 70 80 90 100
0 4 8 12 16 20 24 28 32 36 40
0 2 4 6 8 10 12 14 16 18 20
0 30 60 90 120 150 180 210 240 270 300 330
TIP SPEED OF BLADES FT. PER SEC.

TABLE 22.

DATA AND RESULTS FOR 40" INCH BUFFALO EXHAUSTER 1/2 OPENING OF INTAKE

R.P.M. EXH.	R.P.M. ENG.	SUCTION OZ. PER SQ. IN.	VEL. HEAD IN. WATER	VEL. OF AIR FT. PER. SEC.	AIR DISCH. CU. FT. PER. SEC.	VEE. EXH. TIPS FT. PER. SEC.	H.P. TOTAL	H.P. TO DRIVE EXH.	H.P. THEORETICAL	CU. FT. AIR DISCH. PER H.P. PER SEC	EFF. o/o.
805	77	.76	.32	37.7	54.7	121	2.32	1.92	.68	28.5	35.4
1027	101	1.26	.43	43.7	63.5	122	4.17	3.62	1.55	17.5	42.8
1203	117	1.70	.58	50.5	73.5	182	5.14	4.42	2.04	16.6	46.2
1395	136	2.30	.81	60.5	87.2	212	7.00	6.05	3.27	14.4	52.0
1578	160	3.10	1.08	69.6	101.0	239	10.02	8.77	5.57	11.5	63.0
1782	181	4.00	1.27	75.5	109.6	268	13.85	12.24	7.30	8.2	59.7
1965	205	5.10	1.69	87.0	126.2	296	18.00	15.91	10.50	7.9	65.9
2160	227	6.41	2.23	100.0	145.2	326	24.50	21.95	15.20	6.6	61.4

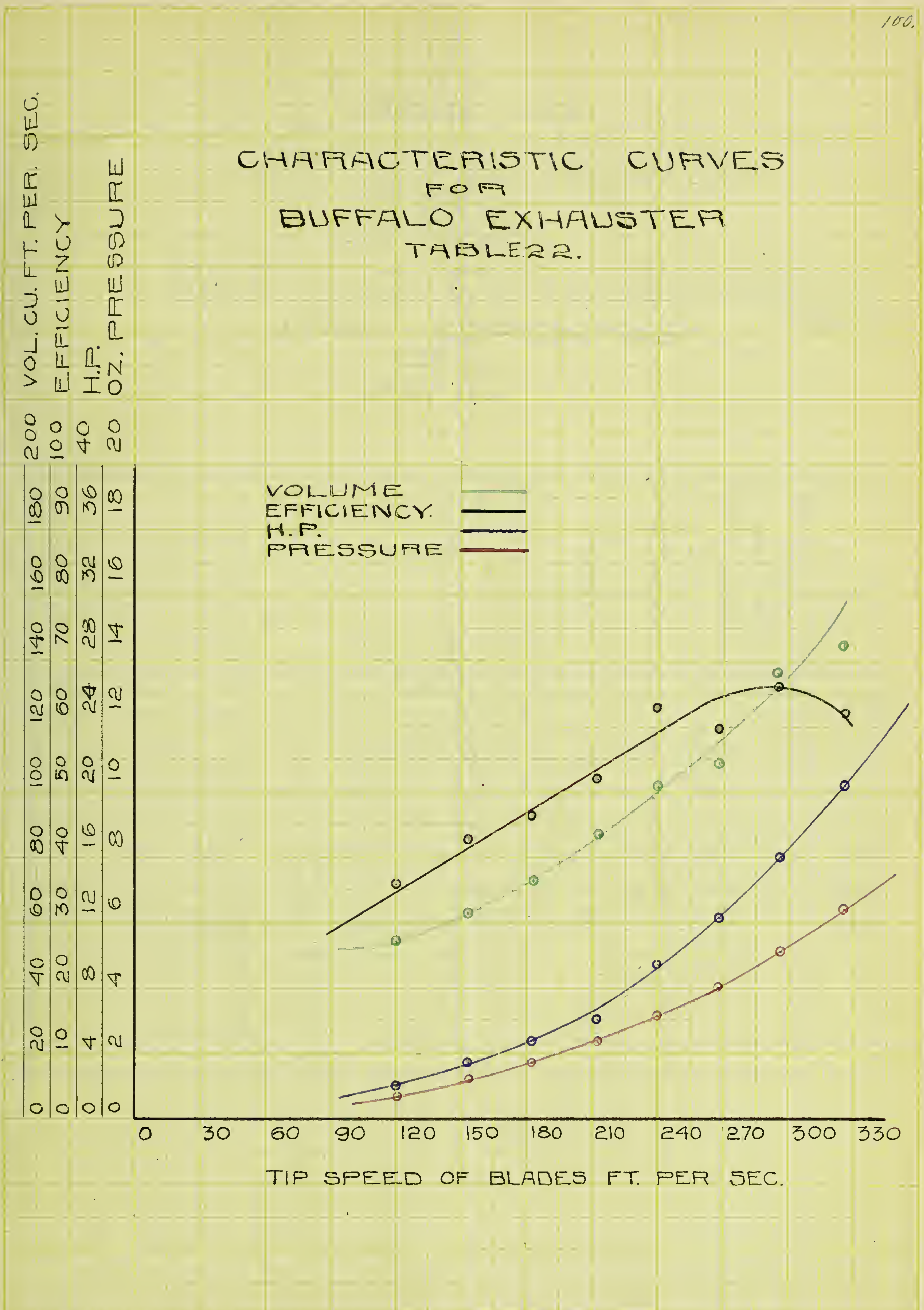

CHARACTERISTIC CURVES
FOR
BUFFALO EXHAUSTER
TABLE 22.
VOLUME
EFFICIENCY
H.P.
PRESSURE
VOL. CU. FT. PER. SEC.
EFFICIENCY
H.P.
OZ. PRESSURE
0 20 40 60 80 100 120 140 160 180 200
0 10 20 30 40 50 60 70 80 90 100
0 4 8 12 16 20 24 28 32 36 40
0 2 4 6 8 10 12 14 16 18 20
0 30 60 90 120 150 180 210 240 270 300 330
TIP SPEED OF BLADES FT. PER SEC.

TABLE 23.

DATA AND RESULTS FOR 40" INCH BUFFALO EXHAUSTER 1/4 OPENING OF INTAKE

R.P.M. EXH.	R.P.M. ENG.	SUCTION OZ. PER SQ. IN.	VEL. HEAD IN. WATER	VEL. OF AIR FT. PER SEC.	AIR DISCH. CU. FT. PER SEC.	VEL. EXH. TIPS FT. PER SEC.	H.P. TOTAL	H.P. TO DRIVE EXH.	H.P. THEORETICAL	CU. FT. AIR DISCH. PER H.P. PER SEC.	EFF. %
805	82	1.00	.17	27.4	39.8	121.3	2.26	1.84	.65	21.6	35.3
1027	100	1.56	.23	31.8	46.2	154.0	3.51	2.96	1.19	15.6	40.0
1220	119	2.20	.34	39.0	56.7	184.0	4.34	3.59	2.05	15.8	57.2
1390	137	3.10	.48	46.2	67.2	210.0	5.07	4.12	3.40	16.3	85.0
1578	160	4.10	.51	47.5	68.9	238.0	7.43	6.18	4.50	11.1	73.2
1772	180	5.20	.56	50.2	72.8	267.0	9.28	7.68	5.00	9.5	65.0
1955	202	6.40	.83	61.0	88.6	295.	11.39	9.29	9.13	9.5	98.3
2160	222	7.80	1.06	69.0	100.2	326	15.50	13.00	12.74	7.7	98.0

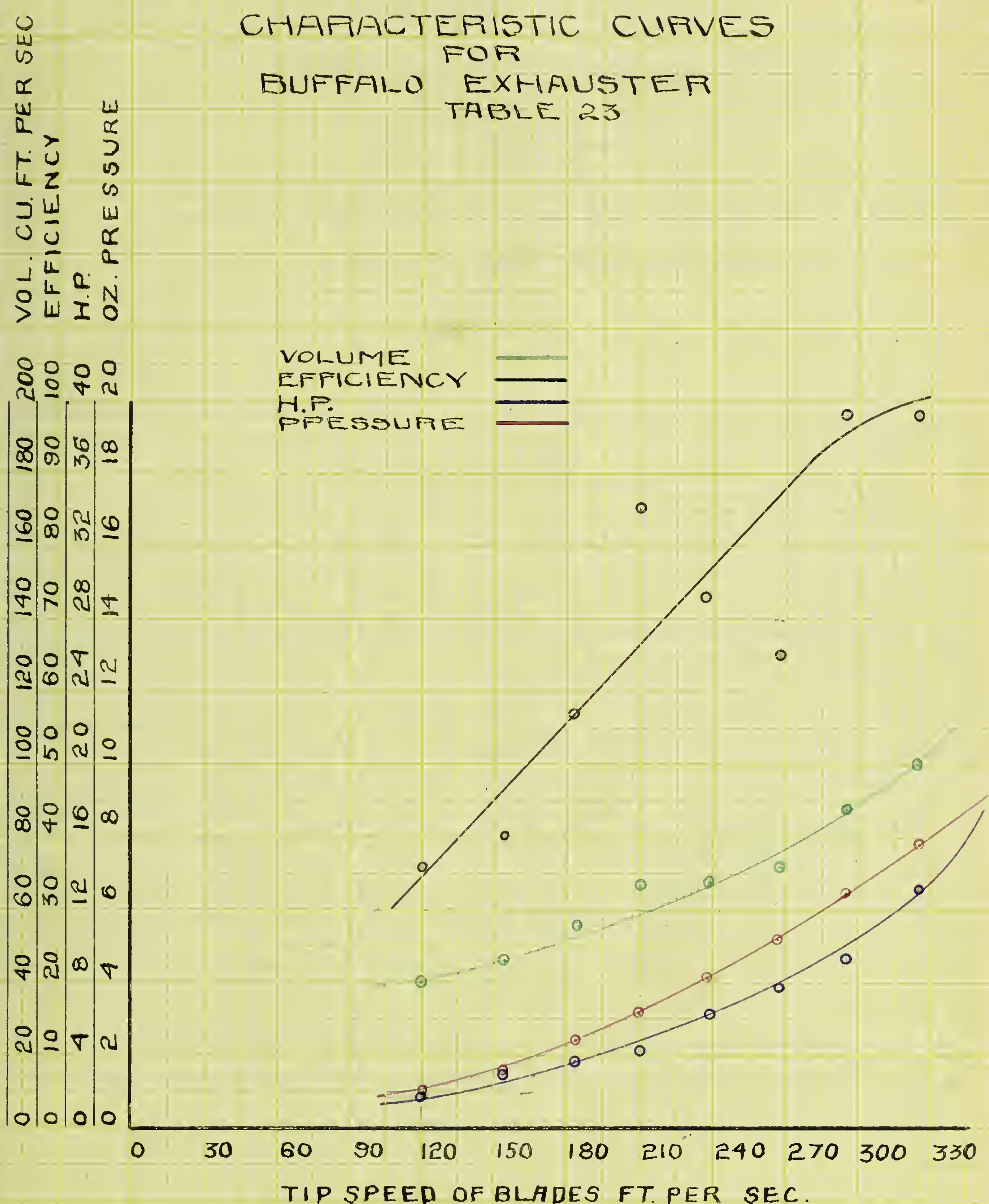
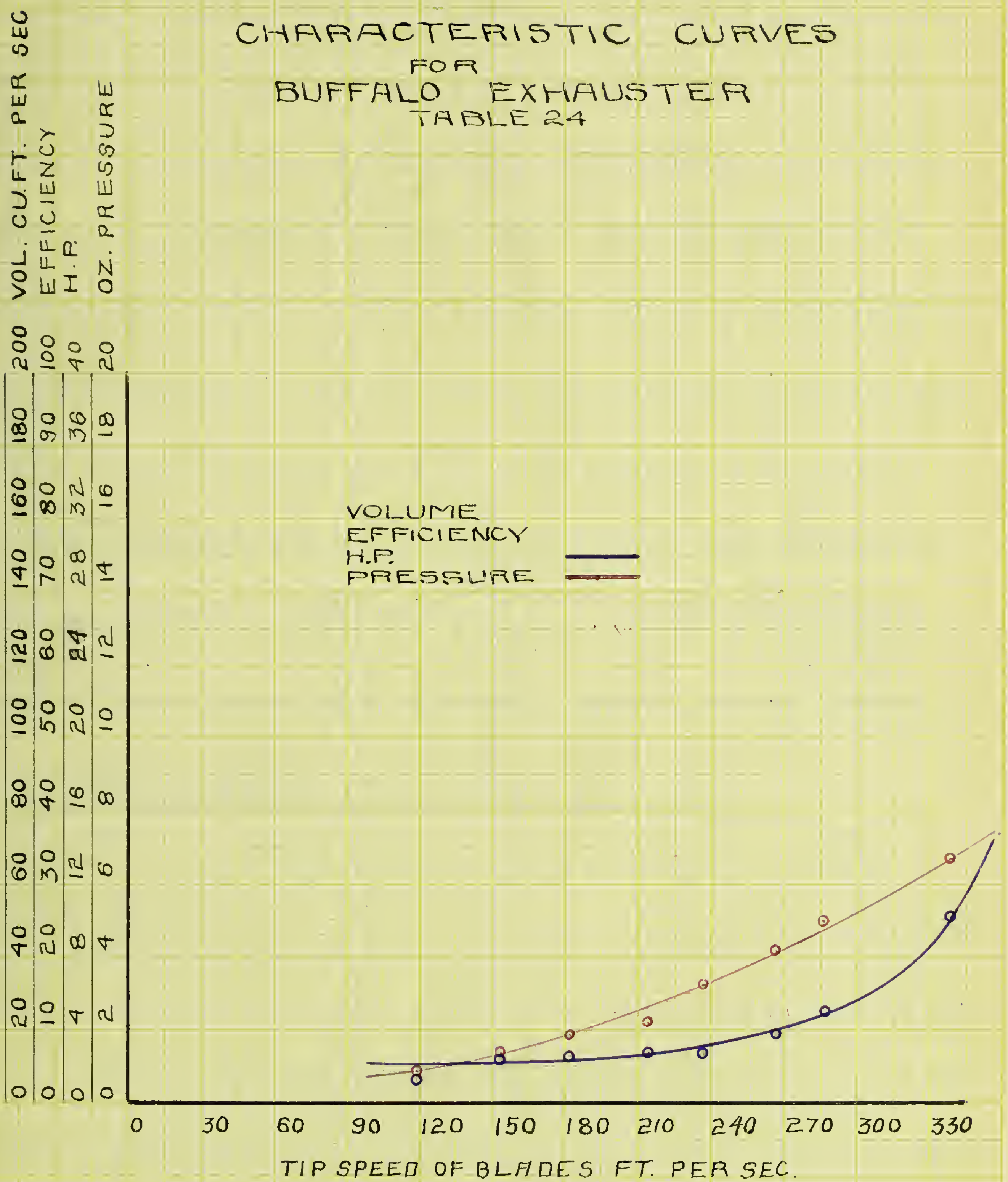

CHARACTERISTIC CURVES
FOR
BUFFALO EXHAUSTER
TABLE 23
VOL. CU. FT. PER SEC
EFFICIENCY
H.P.
OZ. PRESSURE
VOLUME
EFFICIENCY
H.P.
PRESSURE
0 20 40 60 80 100 120 140 160 180 200
0 10 20 30 40 50 60 70 80 90 100
0 4 8 12 16 20 24 28 32 36 40
0 2 4 6 8 10 12 14 16 18 20
0 30 60 90 120 150 180 210 240 270 300 330
TIP SPEED OF BLADES FT. PER SEC.

TABLE 24.

DATA AND RESULTS FOR 40 INCH BUFFALO EXHAUSTER 0 OPENING OF INTAKE

R.P.M. EXH.	R.P.M. ENG.	SUCTION OZ. PER SQ. IN.	VEL. HEAD IN WATER	VEL OF AIR FT. PER SEC.	AIR DISCH. CU. FT. PER SEC.	VEL EXH. TIPS FT. PER SEC.	H.P. TOTAL	H.P. TO DRIVE EXH.	H.P. THEORETICAL	CU. FT. AIR DISCH. PER. H.P. PER. SEC.	EFF. 0/0.
790	78	.86	0	0	0	119	2.15	1.75	0	0	0
1027	100	1.36	0	0	0	154	2.94	2.39	0	0	0
1203	118	1.85	0	0	0	182	3.26	2.53	0	0	0
1405	141	2.16	0	0	0	214	3.71	2.71	0	0	0
1572	157	3.20	0	0	0	237	3.84	2.62	0	0	0
1772	180	4.10	0	0	0	267	5.42	3.82	0	0	0
1895	196	5.00	0	0	0	286	6.80	4.90	0	0	0
2180	225	6.70	0	0	0	239	8.84	6.29	0	0	0


CHARACTERISTIC CURVES
FOR
BUFFALO EXHAUSTER
TABLE 24
VOL. CU.FT. PER SEC
EFFICIENCY
H.P.
OZ. PRESSURE
VOLUME
EFFICIENCY
H.P.
PRESSURE
0 20 40 60 80 100 120 140 160 180 200
0 10 20 30 40 50 60 70 80 90 100
0 4 8 12 16 20 24 28 32 36 40
0 2 4 6 8 10 12 14 16 18 20
0 30 60 90 120 150 180 210 240 270 300 330
TIP SPEED OF BLADES FT. PER SEC.

Results.

Tables and Curves:— The results of each experiment are included in a series of five tables, with the exception of the Sturtevant Blower No. 1, which has only four, because it had only four openings or conditions of its discharge. Characteristic curves, for each table of results, are plotted on the page following the table, for each fan.

Discussion of Results:—

Power Required by the Fan.— By study of the results, it will be found that the maximum power consumed is for the full discharge opening, when the pressure is the lowest, and that the pressure consumed varies

approximately as the square of the speed for each discharge opening. With a closed gate the power necessary to drive the fan is very small, notwithstanding the fact that the pressure is the highest. This is because there is no air passing through the fan.

Pressure:— The pressure is the lowest at the full discharge opening and becomes a maximum at the zero opening. However, for three fourths gate opening the pressure recorded was very often as high as for a closed gate. For quarter opening of the discharge the pressure does not increase so fast in relation to the speed,

as did the H.P. required to drive the fan, while for half opening of the discharge their ratio of increase were about equal. With the three quarter and closed discharge the pressure increased about as the cube of the speed.

Velocity:– In all cases the velocity increased about as the cube of the speed.

Efficiency:– The efficiency is always the lowest for the full gate opening, when the discharge is a maximum. This is due to the fact that the air is discharged at a very low pressure as compared to the other gate openings. The

efficiency increases approximately, directly as the speed and as the size of the discharge opening decreases, up to a certain point, which varies in different fans, and then falls quickly to zero as the gate is closed.